FIG-2

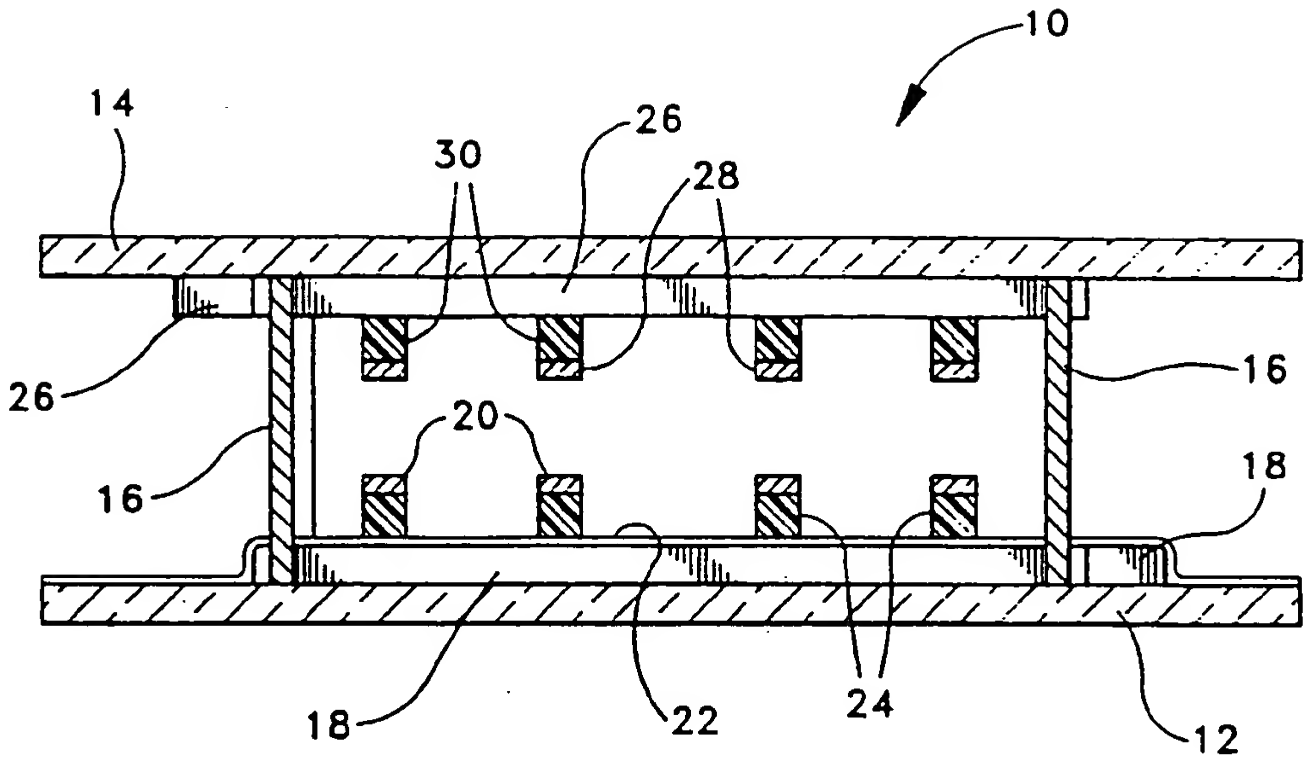


FIG-3

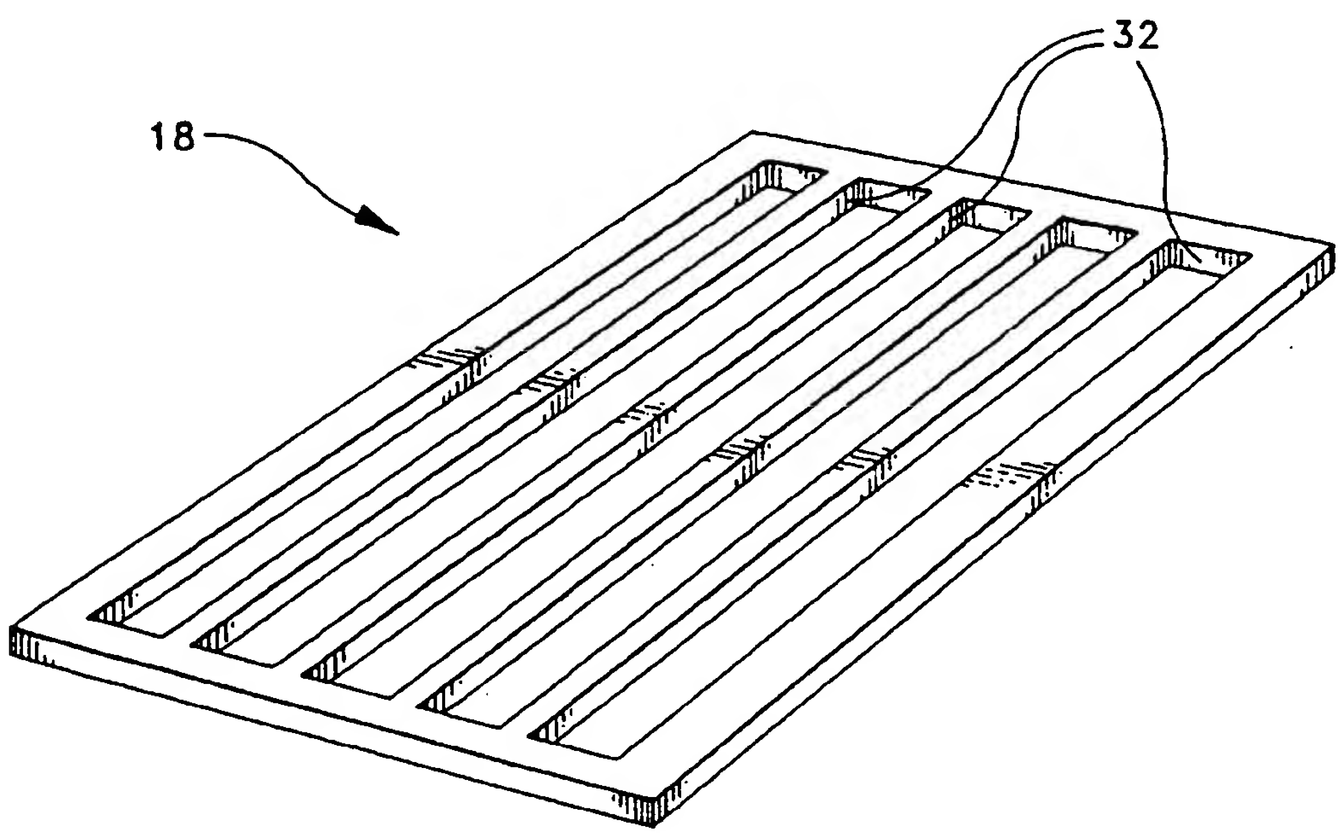
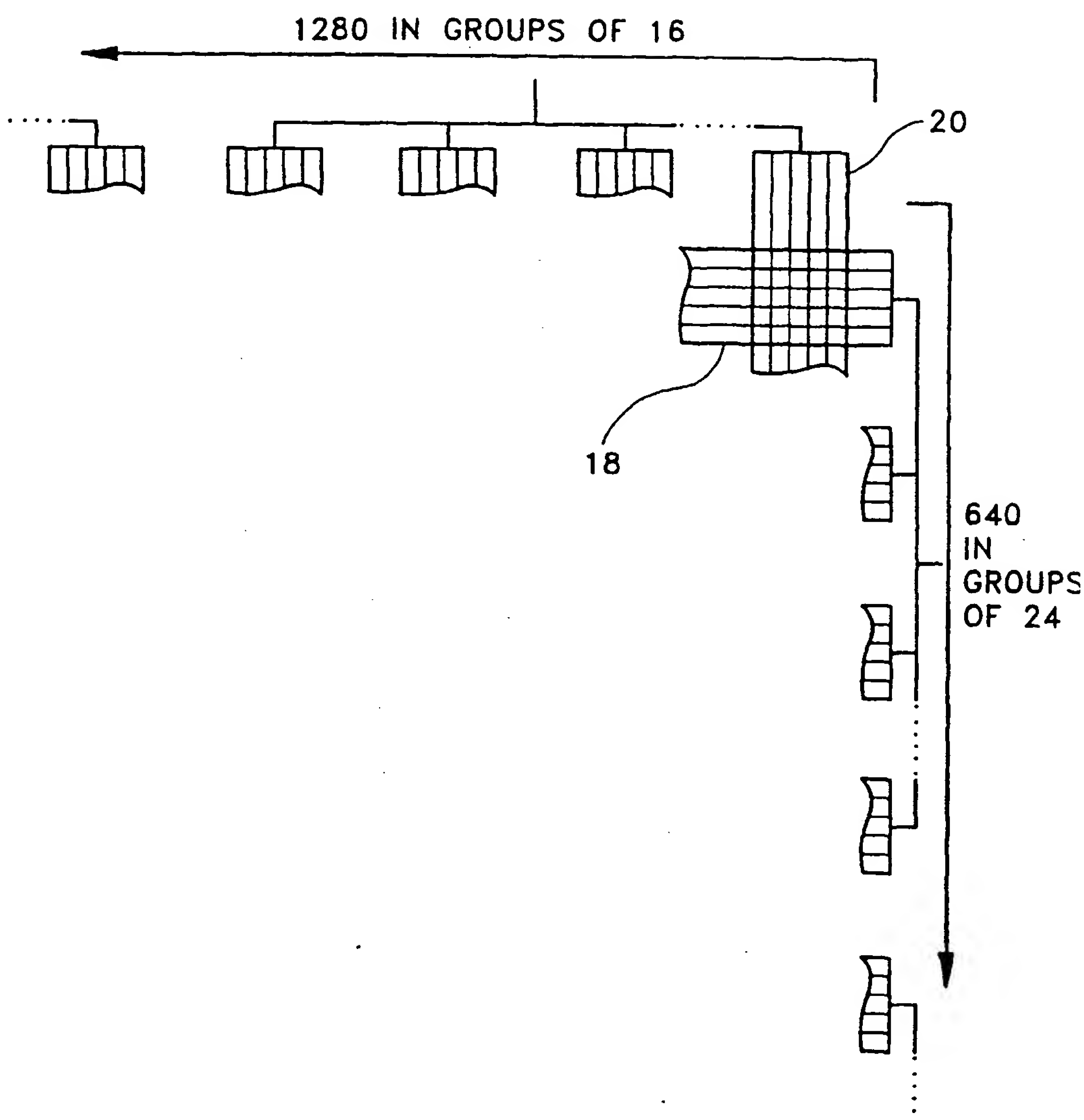


FIG-4



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(54) METHOD FOR WRITING DATA TO AN ELECTROPHORETIC DISPLAY PANEL

SYSTEM ZUM SCHREIBEN VON DATEN AUF EINER ELEKTROPHORETISCHEN ANZEIGETAFEL.

PROCEDE POUR ECRIRE DES DONNEES SUR UN PANNEAU D'AFFICHAGE ELECTROPHORETIQUE

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Description

Technical Field

The present invention relates to a method for operating an electrophoretic display panel apparatus and, more particularly, to a method which increases the speed with which information can be written to an electrophoretic display panel.

Background Art

Electrophoretic displays (EPIDS) are now well known. A variety of display types and features are taught in several patents issued in the names of Frank J. DiSanto and Denis A. Krusos and assigned to the assignee herein, Copytele, Inc. of Huntington Station, New York. For example, U.S Patent Nos. 4,655,897 and 4,732,830, each entitled ELECTROPHORETIC DISPLAY PANELS AND ASSOCIATED METHODS describe the basic operation and construction of an electrophoretic display. U.S. Patent No. 4,742,345, entitled ELECTROPHORETIC DISPLAY PANELS AND METHODS THEREFOR, describes a display having improved alignment and contrast. U.S. Patent No. 4,833,464 entitled ELECTROPHORETIC INFORMATION DISPLAY (EPID) APPARATUS EMPLOYING GREY SCALE CAPABILITY relates to an EPID with the capability to display pixels of varying grey scale intensity. This patent recognizes, inter alia, that the duration of application of a voltage gradient at a particular pixel location effects the quantity of pigment particles at that location. Hence, by controlling the time duration of the write pulse one can achieve grey scale capability - the shorter the pulse, the lighter the line.

The display panels shown in the abovementioned patents operate upon the same basic principle, viz., if a suspension of electrically charged pigment particles in a dielectric fluid is subjected to an applied electrostatic field, the pigment particles will migrate through the fluid in response to the electrostatic field. Given a substantially homogeneous suspension of particles having a pigment color different from that of the dielectric fluid, if the applied electrostatic field is localized, it will cause a visually observable localized pigment particle migration. The localized pigment particle migration results either in a localized area of concentration or rarefaction of particles depending upon the sign and direction of the electrostatic field and the charge on the pigment particles. The electrophoretic display apparatus taught in the foregoing U.S. Patents are "triode-type" displays having a plurality of independent, parallel, cathode row conductor elements or "lines" deposited in the horizontal on one surface of a glass viewing screen. A layer of insulating photoresist material deposited over the cathode elements and photoetched down to the cathode elements to yield a plurality of insulator strips positioned at right angles to the cathode elements, forms the substrate for a plurality of independent, parallel column or grid conductor elements or "lines" running in the vertical direction. A glass cap member forms a fluid-tight seal with the viewing window along the cap's peripheral edge for containing the fluid suspension and also acts as a substrate for an anode plate deposited on the interior flat surface of the cap. When the cap is in place, the anode surface is in spaced parallel relation to both the cathode elements and the grid elements. Given a specific particulate suspension, the sign of the electrostatic charge which will attract and repel the pigment particles will be known. The cathode element voltage, the anode voltage, and the grid element voltage can then be ascertained such that when a particular voltage is applied to the cathode and another voltage is applied to the grid, the area proximate their intersection will assume a net charge sufficient to attract or repel pigment particles in suspension in the dielectric fluid. Since numerous cathode and grid lines are employed, there are numerous discrete intersection points which can be controlled by varying the voltage on the cathode and grid elements to cause localized visible regions of pigment concentration and rarefaction. Essentially then, the operating voltages on both cathode and grid must be able to assume at least two states corresponding to a logical one and a logical zero. Logical one for the cathode may either correspond to attraction or repulsion of pigment. Typically, the cathode and grid voltages are selected such that only when both are a logical one at a particular intersection point, will a sufficient electrostatic field be present at the intersection relative to the anode to cause the writing of a visual bit of information on the display through migration of pigment particles. The bit may be erased, e.g., upon a reversal of polarity and a logical zero-zero state occurring at the intersection coordinated with an erase voltage gradient between anode and cathode. In this manner, digitized data can be displayed on the electrophoretic display.

An alternative EPID construction is described in Application No. 07/345,825 entitled DUAL ANODE FLAT PANEL DISPLAY APPARATUS and filed on May 1, 1989 for the assignee herein, which relates to an electrophoretic display in which the cathode/grid matrix as is found in triode-type displays is overlayed by a plurality of independent separately addressable "local" anode lines. The local anode lines are deposited upon and aligned with the grid lines and are insulated therefrom by interstitial lines of photoresist. The local anode lines are in addition to the "remote" anode, which is the layer deposited upon the anode faceplate or cap as in triode displays. The dual anode structure aforesaid provides enhanced operation by eliminating unwanted variations in display brightness between frames, increasing the speed of the display and decreasing the anode voltage required during Write and Hold cycles, all as explained in Application No. 07/345,825.

A commonly sought objective for EPIDS of both triode and tetrode types, and for digital display equipment

and computer and digital apparatus in general, is increased speed of operation. With respect to displays, it is desirable for the display to be able to write, erase and edit the displayed image as quickly as possible in response to operator input and computer processing. For example, when a computer with a visual output device for displaying character information, such as a CRT, is used as a word processor, if the writing and erasure of displayed information is not fast enough, it will slow the operator of the word processor in the completion of his task. Even though the computer memory and processing unit can operate at speeds far exceeding the capacity of a human user, if the input and output devices through which the computer communicates with the user are slow, the computer and the user must wait for the output devices. Thus, if a word processor user is paging through a document at high speed, a slow visual output device may well slow the speed of paging below that at which the user and/or the computer could potentially perform.

In EPIDS and in other display apparatus, because there are a plurality of pixels arranged on a coordinate grid or matrix, and because the pixels must be independently addressable, display operations are frequently conducted at the pixel level, e.g., each pixel is sequentially written to. Sequential operations are intrinsically time consuming, in that the prior operation must be completed before the subsequent can be started. Further, even though the writing of a single pixel can be done very quickly, there are such a large number that even a small write time is significant. A process for independently controlling individual pixel display whereby a degree of parallel display processing is accomplished is described, e.g., in U.S. Patent No. 4,742,345, wherein display information pertaining to an entire line of pixels, i.e., On or Off, is accumulated in an accumulator or register during a first phase, placed in parallel into a latch array in a second phase and placed in parallel on one of the coordinate grids in a third phase. Placing the display information onto one of the coordinate line sets, e. g., the grid lines which may be oriented in the vertical direction, has been termed "loading" the data on the grid. When the bits of information (voltages corresponding to logical "1" and "0") are placed or "loaded" on, e. g., all the vertical coordinate lines, a single horizontal line can be written by enabling that line, i.e., by placing a voltage corresponding to a logical "1" on that horizontal line. The operation of placing an enabling voltage upon the line to be written, in this case a horizontal cathode line, has been referred to as "writing the line". Of course, this line-by-line writing method also has a upper limit of speed.

With respect to EPIDS, one factor which contributes to the speed with which the display can operate is the speed with which the pigment particles can travel through the electrophoretic fluid under the influence of a particular voltage gradient. Pigment particle migration speed depends, inter alia, upon particle size and electrophoretic fluid viscosity. In addition to the particle speed, there is also the factor of spatial distribution within the EPID envelope, i.e., because the particles are in suspension they are distributed, prior to being exposed to voltage gradients, relatively evenly within the fluid envelope. Accordingly, there is a range of particle proximity to the "target" element, the target element being that element to which the particles are sought to be directed to perform an operation, such as write or erase.

These speed and proximity factors in EPIDS are utilized in U.S. Patent No. 4,833,464 to control pixel display intensity or grey scale. Namely, if a voltage gradient of shorter or longer duration is applied, fewer or greater particles will accumulate at the "target" electrode thereby affecting pixel intensity, i.e., the greater the number of particles, the greater the intensity. Note that pixel intensity is discernable at both sides of the typical EPID so that an intense accumulation of e.g., light colored particles, on one face of the EPID is accompanied by a correspondingly intense lack of light particles on the other face, which, in all probability, will appear dark due to the selection of a dark solution or background for the light colored particles. Thus writing a character on one faceplate of an EPID results in its reverse image being written on the other plate. The writing of a blank character may be termed selective character erasure.

In US 4804951 there is disclosed a display in which alternate lines of a frame of display data are written by a first electrode scan, and the remaining lines are written by a second electrode scan. such that a second of a pair of adjacent lines can be written immediately sequentially, without having to wait for the first electrode scan to "flyback" before writing the second of the lines. However, it is still necessary to perform the same number of scans to write the entire display frame and hence there is no substantial saving in the overall time for writing the display frame.

It is an objective of the present invention to provide a method for operating an EPID having any particular pigment particle size, electrophoretic fluid viscosity, electrode arrangement and operating voltage levels, such that the speed of operation is increased.

Disclosure of the Invention

The problems and disadvantages associated with conventional methods of operating electrophoretic displays are overcome by the present inventive method which enables a decrease in the time to write a frame of display data composed of a plurality of lines of displayable pixels on an electrophoretic display requiring a minimum time period for a line to be fully written.

According to the invention we provide a method for decreasing the time period to write a frame of display data composed of a plurality of lines of displayable pixels, on a high line density electrophoretic display requiring a predetermined time period for a line to be fully written, said method comprising the steps of:

(a) simultaneously writing a set of at least two adjacent lines with said display data in a first time period which is less than said predetermined time period for a line to be fully written;

(b) shifting the elements of said line set such that said set includes at least one new line and at least one original line;

(c) writing said shifted line set in a second time period which is less than said predetermined time period, following said step of shifting; and

(d) repeating steps (b) and (c) until said frame is completely written.

Brief Description of the Drawings

For a better understanding of the present invention, reference is made to the following detailed description of an exemplary embodiment considered in conjunction with the accompanying drawings, in which:

FIG. 1 is a cross-sectional view of a typical triode-type EPID showing the essential electrical components thereof.

FIG. 2 is a simplified schematic diagram illustrating an addressable display matrix comprised of horizontal and vertical elements, such as, a plurality of cathode lines and a plurality of grid lines, driven by display drivers, as would be used in known EPID devices like that shown in FIG. 1.

FIG. 3 is a simplified schematic diagram illustrating circuitry for controlling the x and y display drivers illustrated in FIG. 2.

FIG. 4 shows a character which could be displayed upon an x-y matrix using the circuitry and apparatus as illustrated in FIGS. 1-3, as controlled and operated in accordance with the method of the present invention.

FIG. 5 is a flowchart showing a method for EPID writing in accordance with the present invention.

Carrying Out The Invention

FIG. 1, which is taken from U.S. Patent No. 4,732,830, shows an electrophoretic display 10 as is now known in the art. The display 10 has an anode faceplate 12 and a cathode faceplate 14 which are sealably affixed on either side of an interstitial spacer (not shown) to form a fluid-tight envelope for containing a dielectric/pigment particle suspension or electrophoretic fluid. The faceplates 12 and 14 are typically flat glass plates upon which are deposited conductor elements to comprise the situs of electrostatic charge for inducing motion of the pigment particles 16 in the electrophoretic fluid. The techniques, materials and dimensions used to form the conductor elements upon the faceplates and the methods for making and using EPIDS, in general, are shown in U.S. Patent Nos. 4,655,897, 4,732,830 and 4,742,345.

Known EPIDS, as depicted in FIG. 1, for example, have a plurality of independent, electrically conductive cathode lines 18, shown here as horizontal rows, deposited upon the cathode faceplate 14 using conventional deposition and etching techniques. Of course, the orientation of the cathode lines 18 depends upon the orientation of the screen, which, if rotated 90 degrees, would position the cathode lines vertically. Thus, the cathode lines are arbitrarily defined as horizontal or in the x-axis. It is preferred that the cathode elements 18 be composed of Indium Tin Oxide (ITO) as set forth in U.S. Patent No. 4,742,345. A plurality of independent grid conductor lines 20 are superposed in the vertical (parallel with the γ-axis) over the cathode elements 18. i.e. at right angles thereto, and are insulated therefrom by an interstitial photoresist layer 22. The grid elements 20 may be formed by coating the photoresist layer 22 with a metal, such as nickel or chrome, using sputtering techniques or the like, and then selectively masking and etching to yield the intersecting but insulated configuration shown in FIG. 1. Each cathode and grid element 18, 20 terminates at one end in a contact pad, or is otherwise adapted to permit connection to display driver circuitry. An anode 26 is formed on an interior surface of the anode faceplate 12 by plating with a thin layer of conductor material, such as, chrome.

The foregoing components have been previously described in prior patent and applications of the present Applicants. In addition to these teachings, the benefits and operation of an EPID having a local anode have been recognised and described in Application No. 07/345,825 by the present Applicants. The present inventive method could find application in any of these disclosed devices.

FIG. 2, also taken from U.S. Patent No. 4,732,830, shows, in the simplest schematic form, how the cathode 18 and grid lines 20 comprise an addressable x-y matrix allowing pixels at the intersection points to be selectively displayed. Each horizontal 18 and vertical 20 line has an associated amplifer/driver 24R and 24C, respectively, for impressing either a logical "1" or "0" thereon, such that when both are "1" at an intersection, that intersection is written. The horizontal lines have been labelled R1...R2200 to signify that 2200 display lines 18 or rows would typically be present. 1700 vertical lines 20 or columns are common, as depicted by the labels C1... C1700.

FIG. 3, taken from Patent No. 4,742,345, shows exemplary circuitry for suplying input data to the x and y drivers, 24R and 24C. As explained fully in patent No. 4,742,345. a large capacity, composite, serial-to-parallel register 26 may be used as a buffer for collecting a large number of bits of display data, e.g. 850 bits. After sequentially clocking data into the register 26 and filling it to capacity, the data is latched in parallel into a latch array 28 having an equal capacity. The data is then strobed into the display driver amplifiers 24 through a plurality of AND gates 30. Data may be accumulated in the serial register while the transfer from latch array 28 to drivers 24 occurs. In FIG. 3 the output of the AND

gates are labelled with odd number columns 1 through 1699. The data for even number columns would be supplied, in this case, by a twin circuit disposed on the cathode faceplate opposite to that for the odd columns. This configuration prevents overcrowding of electrical connections to the grid lines as explained in Patent No. 4,742,345. Once the column data is supplied to all columns, a row can then be written by sending a "1" along the row or cathode 18 to be written. The row "1" in combination with any column "1" will cause the writing of a pixel at the intersection thereof, i.e., a voltage gradient at that point sufficient to cause a visually observable migration and agglomeration of pigment particles 16.

The proportions of the grid 20 and cathode 18 lines as shown in FIGS. 1 and 2 have been greatly enlarged for the purposes of illustration. In operational displays, the grid 20 and cathode 18 lines are very thin and elongated. A workable panel would have a large number of intersections, e.g., 2,200 X 1,700 or a total of 3,740,000 separately addressable intersection points in a panel approximately 8" X 11". For ease of illustration, only a few cathode lines 18, and grid lines 20 are depicted. Additional illustrations of electrophoretic displays, their components and electrical circuitry can be seen by referring to U.S. Patents Nos. 4,742,345 and 4,772,820, each being awarded to the inventors herein.

FIG. 4 illustrates a character, i.e. the letter "T" written on a EPID as described above in reference to FIGS. 1-3 by utilizing the algorithm flow chartered in FIG. 5. In accordance with the present inventive method, it has been observed that the writing time of the EPID can be reduced by simultaneously writing more than one line at a time. That is, in the above-described previously known EPIDS, an entire set of column data for a particular row is impressed upon the columns, e.g. the grid lines. A single row is then enabled with a logica "1" and thereby written. The next set of column data is loaded onto the grid lines and the next row is enabled or written. This goes on sequentially until the entire screen is written. There is a certain period required for the pigment particles to migrate through the electrophoretic fluid to their "write" position, i.e., to make an agglomeration sufficient in size to be clearly visible. Therefore each row in pas operation had to be held in the logical "1" state for the required writing period or writing cycle time. In accordance with the present invention, if a set of rows greater than one row, e.g., two rows, is enabled simultaneously for a period approximately one-half as long in duration as was previously done, then the two rows will both be dimly written with the same display information in one half the cycle time. For instance, if column data for row 1 is loaded and rows 1 and 2 are written, both row 1 and row 2 will be dimly written with row 1 display information. If new column data, i.e., for row 2, is loaded and the row set is shifted down one and written, i.e., row set 2 and 3 are written using row 2 data, the first row which was half-written will be left untouched. The second row, however, will be fully written assuming the new column data associated with row 2 is the same as that associated with row 1. Row 3 is also dimly written with row 2 data. Thus, by partially writing subsequent overlapping row sets with shortened writing cycles, the entire display can be written much faster than if single rows are sequentially fully written. This row set writing strategy depends upon the fact that there is repetition in the pixel pattern from one row to the next. In fact, there is a high probability of that condition occurring. Because of high line density in the EPIDS in question, the number of lines comprising a single character is great. For example, a 70 line X 25 line matrix with 1750 pixels may be used as the area for expressing a single character. As such, the pattern of pixels comprising the common characters is very repetitive. Fig. 4 illustrates this principle using a matrix of only 22 X 22 lines, i.e., those lines centrally located within the entire 29 X 31 line matrix depicted. The top of the "T" begins at (r5,c5) and ends at (r9,c26). The significance of the X's on row 5 will be explained below. The stem of the "T" starts at (r10,c13) and ends at (r26,c17). As can readily be seen, the top of the "T" is composed of 5 identical rows of pixels and the stem of the "T" is composed of 17 identical rows of pixels. The "T" depicted in FIG. 4 is an example of applying the present inventive method in writing in two row sets at one half the normal write cycle time (twice the writing speed). Specifically, one would execute the following steps in order to display the "T" shown in FIG. 4.:

Load c1-c29 with data for r1
(0,0,0,0,0,0,0,0.......0)
Write r1 and r2 simultaneously (put "1" on r1 and r2)
Load c1-c29 (the grid lines) with data for r2
(0,0,0,0,...0)
Write r2,r3
Load grid with r3 data
Write r3, r4
Load grid with r4 data
Write r4,r5

Note: for the purposes of this example, r5 has been selected as the first line that has "ls" or written pixels in it and it should be the first line of the "top" of the "T". Due to the fact, however, that r5 is a transition line, i.e., a transition from non-written to written pixels, it will not be completely written and instead will only be dimly written or half written. This is so because each write cycle, since it is at twice the speed as a normal cycle, only "half writes" the information. The next cycle is necessary to fully write the information, but only if the next cycle uses the same data. In the case of a transition line, succeeding rows have different data. Since there are so many lines of pixels in operable displays, the loss of small numbers of transition lines and/or pixels does not cause a significant loss in readability. Returning now to the writing process:

Load grid with r5 data
(0,0,0,0,1,1, 1,1,1,1,1,1...1,0,0,0)
Write r5,r6
Load grid with r6 data (same as r5 data)

Write r6, r7 (since r6 was previously "half" written with r5 data in the prior cycle and since the r5 data was the same as the r6 data, r6 is written completely on the subsequent cycle.)
Load r7 data
Write r7,r8
Load r8
Write r8,r9
Load r9
Write r9,r10 (r10 is another partial transition line, i.e., it is the transition from the top of the "T" to the stem of the "T". Since the r9 data is written on line 10, a portion thereof, i.e., that which should contain non-written pixels - the X's - will be dimly or half written.)
Load r10
Write r10,r11
repeats until row 26 where:
Load r26
Write r26,r27 (constitutes another transition line)
Write r27, r28, etc.
Load r27

The foregoing should illustrate one embodiment of the present inventive method. Further, it can be understood that in lieu of two line set writing, three, four, or more lines can be written simultaneously with corresponding increases in speed and in transition lines which will be of varying intensity depending upon the number of repetitions of writes to those transition lines. For example, in four line set writing, when a transition from blank to written pixels occurs, there are three transition lines, the first being the dimmest and the last, the darkest. The fourth line written will be fully written. Similarly, in a transition from written to non-written pixels, there will be three transition lines, the first being the darkest and the last the dimmest. The fourth line will be non-written. Of course, in four line set writing, the benefit of increasing writing speed over the normal speed would be utilized to produce a fourfold increase in speed.

FIG. 5 is a generalized flowchart of the steps of the present inventive method for operating an EPID in a multi-line write mode. It would be expected that operator selection of display writing speed would be offered so that the operator can choose the speed and clarity. This sort of selection is presently offered to operators upon printing on dot-matrix printers, i.e. enhanced printing has greater pixel density but takes longer to print. Accordingly, the operator first enters the number of lines to be written in each write cycle 32. From, this input the write cycle time (writing speed) is adjusted 34. The greater the number of lines simultaneously written in each write cycle, the faster the writing speed. Of course, the operator input could be expressed as a selection of writing speed, wherein the operator would select from a range of speeds corresponding to the number of lines simultaneously written. The flowchart shown in FIG. 5 pertains to the display of a single complete image (frame) on the EPID. This algorithm would be utilized over and over under the control of programming at the next higher level. The operator would not be queried as to the operating speed on each frame displayed. Information of that type would be initially set by query or default then changed by interrupt if desired. Having determined the line set size for writing, the writing is begun at the first row 36. (Of course, it would be equally feasible to load rows with data and write columns.) The processor then enters a loop wherein data for the current row is loaded onto the column lines (here grid lines) 38. The data is simultaneously written on the current row and the next x-1 rows by enabling those rows with a logical "1" 40, x being the number of rows in the write set selected. Thus, on the first write cycle in a 4 line set write mode, row 1 and the next (4-1) or 3 rows, i.e., rows 2, 3 and 4 are written. Note that the "1" state may correspond to a variety of voltages depending upon the EPID in question, e.g., whether the EPID is a triode or tetrode. A voltage of 0 volts has been used to enable writing in triodes and, in those instances, represent a logical "1" or enable state. The row set is written for a write cycle time that has been adjusted by the size of the row set (divided by). This is continued until all rows are written 42,44, whereupon control is returned to the next higher level in the program. Of course, other line writing sequences could be employed using a multi-line write strategy, for example, vertical lines can be written from left to right or right to left, horizontal lines could be written from bottom to top or from the middle to the outer periphery, etc.

Claims

1. A method for decreasing the time period to write a frame of display data (36,38) composed of a plurality of lines (20) of displayable pixels, on a high line density electrophoretic display (10) requiring a predetermined time period for a line to be fully written, said method comprising the steps of:

   (a) simultaneously writing (40) a set of at least two adjacent lines (20) with said display data (36,38) in a first time period which is less than said predetermined time period for a line to be fully written;
   (b) shifting the elements (44) of said line set such that said set includes at least one new line and at least one original line;
   (c) writing said shifted line set (40) in a second time period which is less than said predetermined time period, following said step of shifting (44); and
   (d) repeating steps (b) and (c) until said frame is completely written.

2. The method of Claim 1, wherein each of said first and second time periods decreases in duration with increasing numbers of said elements in said line

set.

3. The method of Claim 2, wherein each of said first and second time periods approximates said predetermined time period divided by the number of elements in said line set.

4. The method of Claim 1, wherein said pixels of said original line are written at a pixel intensity, which approximates to a predetermined pixel intensity for a pixel written for said predetermined time period for a line to be fully written, when said new line contains pixels of a predetermined displacement.

5. The method of Claim 4, wherein the method further includes the step of selecting the number of lines in said set (32).

6. The method of Claim 5, wherein the method further includes the step of adjusting the duration of said time period (34), which is less than said predetermined time period for a line to be fully written, when a change in the number of lines in said set occurs.

7. The method of Claim 6, wherein said predetermined displacement is equal to the displacement of a reference line that is located on an edge of said display (10).

Patentansprüche

1. Verfahren zur Verkürzung der Zeitdauer zum Schreiben eines Rahmens von Anzeigedaten (36, 38), der aus einer Mehrzahl von Zeilen (20) von anzeigbaren Bildpunkten besteht, auf einer elektrophoretischen Anzeige (10) mit hoher Zeilendichte, die eine vorbestimmte Zeitdauer zum vollständigen Schreiben einer Zeile erfordert, wobei das besagte Verfahren folgende Schritte umfaßt:

   (a) gleichzeitiges Schreiben (40) einer Menge von mindestens zwei benachbarten Zeilen (20) mit besagten Anzeigedaten (36, 38) in einer ersten Zeitdauer, die kürzer als die besagte vorbestimmte Zeitdauer zum vollständigen Schreiben einer Zeile ist;
   (b) Verschieben der Elemente (44) der besagten Zeilenmenge, so daß die besagte Menge mindestens eine neue Zeile und mindestens eine Ursprungszeile enthält;
   (c) Beschreiben der besagten verschobenen Zeilenmenge (40) in einer zweiten Zeitdauer, die kürzer als die besagte vorbestimmte Zeitdauer ist, nach dem besagten Schritt des Verschiebens (44); und
   (d) Wiederholen der Schritte (b) und (c), bis der besagte Rahmen vollständig geschrieben ist.

2. Verfahren nach Anspruch 1, wobei die Länge jeder der besagten ersten und zweiten Zeitdauern mit steigenden Anzahlen der besagten Elemente in der besagten Zeilenmenge abnimmt.

3. Verfahren nach Anspruch 2, wobei jede der besagten ersten und zweiten Zeitdauern annähernd die besagte vorbestimmte Zeitdauer geteilt durch die Anzahl von Elementen in der besagten Zeilenmenge ist.

4. Verfahren nach Anspruch 1, wobei die besagten Bildpunkte der besagten Ursprungszeile mit einer Bildpunktintensität geschrieben werden, die sich einer vorbestimmten Bildpunktintensität für einen Bildpunkt nähert, der die besagte vorbestimmte Zeitdauer zum vollständigen Schreiben einer Zeile lang geschrieben worden ist, wenn die besagte neue Zeile Bildpunkte mit einem vorbestimmten Versatz enthält.

5. Verfahren nach Anspruch 4, wobei das Verfahren weiterhin den Schritt des Auswählens der Zeilenzahl in der besagten Menge enthält (32).

6. Verfahren nach Anspruch 5, wobei das Verfahren weiterhin den Schritt des Einstellens der Länge der besagten Zeitdauer (34) enthält, die kürzer als die besagte vorbestimmte Zeitdauer zum vollständigen Schreiben einer Zeile ist, wenn eine Änderung der Zeilenzahl in der besagten Menge eintritt.

7. Verfahren nach Anspruch 6, wobei der besagte vorbestimmte Versatz gleich dem Versatz einer Bezugszeile ist, die sich an einem Rand der besagten Anzeige (10) befindet.

Revendications

1. Procédé de diminution de la période de temps d'écriture d'une trame de données d'affichage (36,38) composée d'une pluralité de lignes (20) de pixels affichables, sur un affichage électrophorétique à grande densité de lignes (10) exigeant une période de temps prédéterminée pour l'écriture complète d'une ligne, ledit procédé comprenant les étapes de:

   (a) écriture simultanée (40) d'un ensemble d'au moins deux lignes adjacentes (20) avec lesdites données d'affichage (36,38) dans une première période de temps qui est inférieure à ladite période de temps prédéterminée pour l'écriture complète d'une ligne;
   (b) décalage des éléments (44) dudit ensemble de lignes de telle sorte que ledit ensemble comporte au moins une nouvelle ligne et au moins

une ligne originale;
(c) écriture dudit ensemble de lignes décalé (40) dans une deuxième période de temps qui est inférieure à ladite période de temps prédéterminée, à la suite de ladite étape de décalage (44); et
(d) répétition des étapes (b) et (c) jusqu'à ce que ladite trame soit complètement écrite.

2. Procédé de la revendication 1, dans lequel la durée de chacune desdites première et deuxième périodes de temps diminue avec l'augmentation des nombres desdits éléments dans ledit ensemble de lignes.

3. Procédé de la revendication 2, dans lequel chacune desdites première et deuxième périodes de temps approxime ladite période de temps prédéterminée divisée par le nombre d'éléments dans ledit ensemble de lignes.

4. Procédé de la revendication 1, dans lequel lesdits pixels de ladite ligne d'origine sont écrits à une intensité de pixel, qui approxime une intensité de pixel prédéterminée d'un pixel écrit pendant ladite période de temps prédéterminée pour l'écriture complète d'une ligne, quand ladite nouvelle ligne contient des pixels d'un déplacement prédéterminé.

5. Procédé de la revendication 4, dans lequel le procédé comporte en outre l'étape de sélection du nombre de lignes dans ledit ensemble (32).

6. Procédé de la revendication 5, dans lequel le procédé comporte en outre l'étape de réglage de la durée de ladite période de temps (34), qui est inférieure à ladite période de temps prédéterminée pour l'écriture complète d'une ligne, quand un changement du nombre de lignes dans ledit ensemble se produit.

7. Procédé de la revendication 6, dans lequel ledit déplacement prédéterminé est égal au déplacement d'une ligne de référence qui est située sur un bord dudit affichage (10).

FIG-1

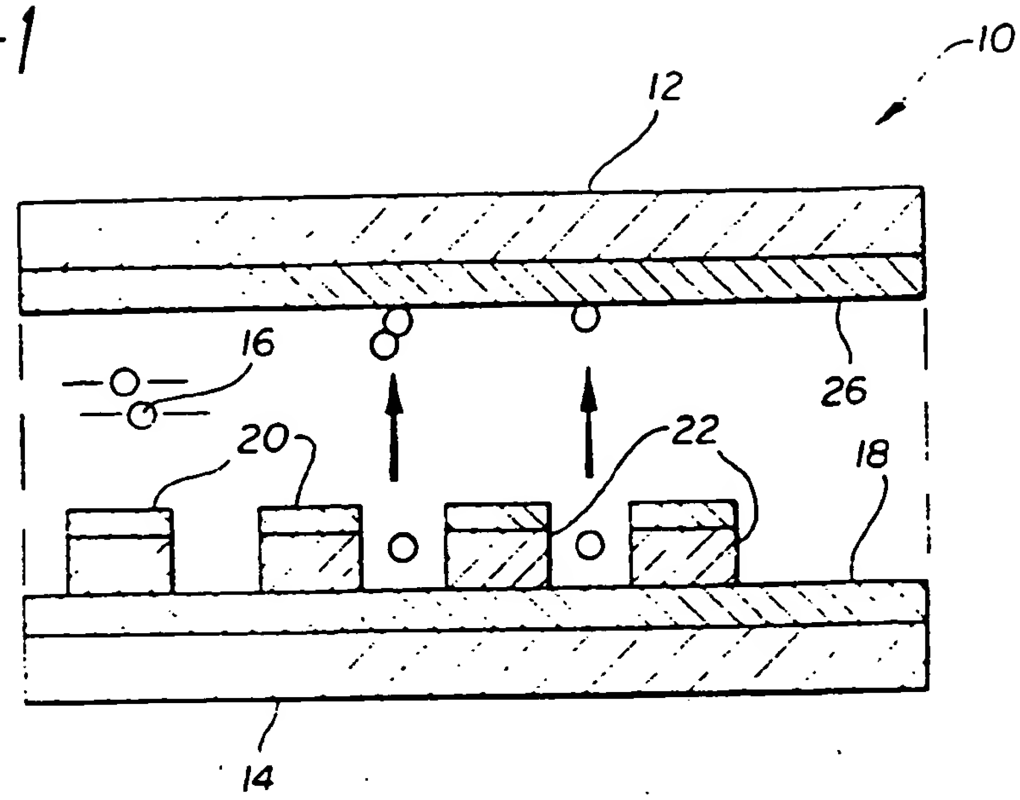

10
12
16
26
20
22
18
14

FIG-2

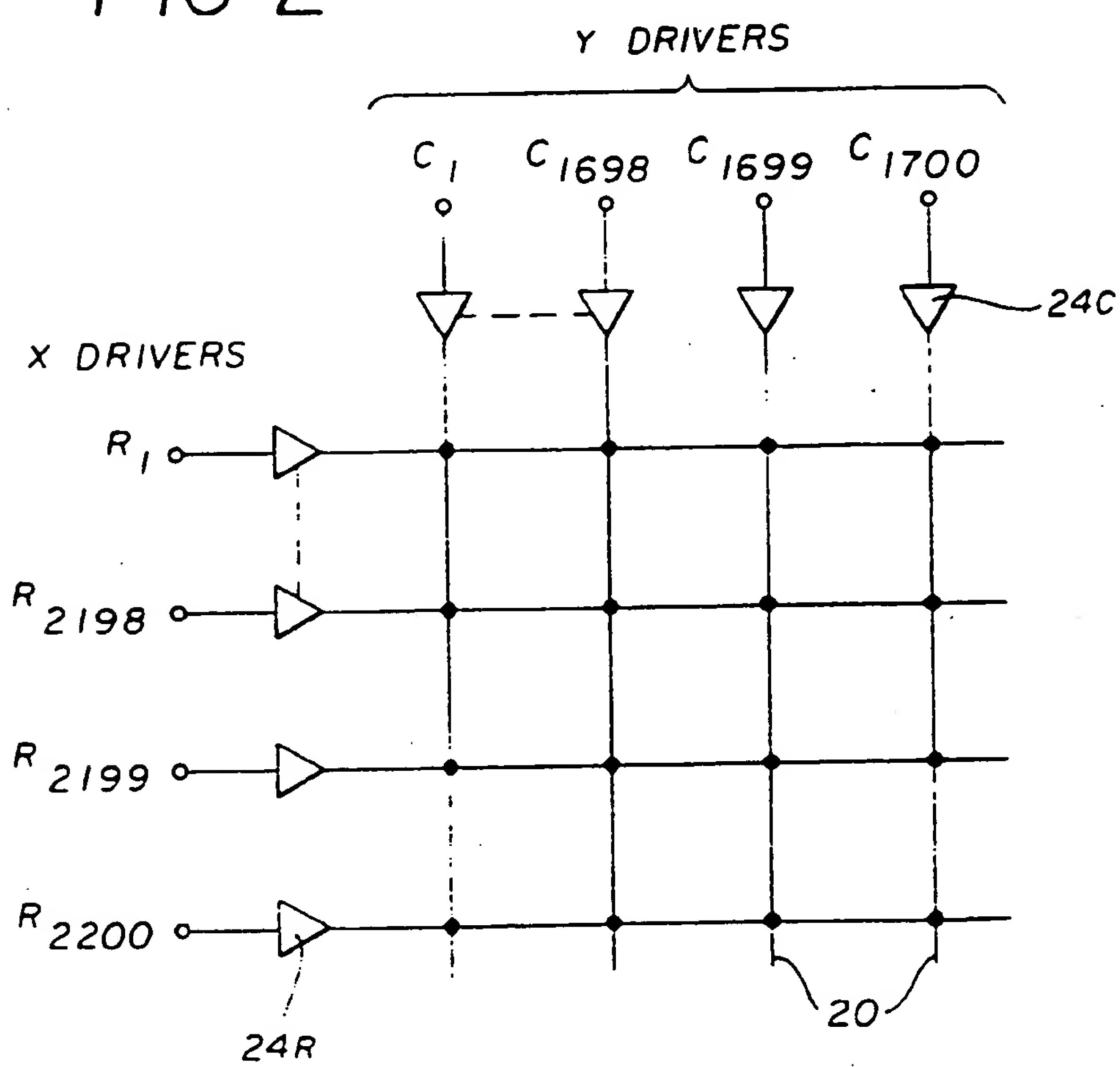

Y DRIVERS
C1
C1698
C1699
C1700
24C
X DRIVERS
R1
R2198
R2199
R2200
24R
20

FIG-3

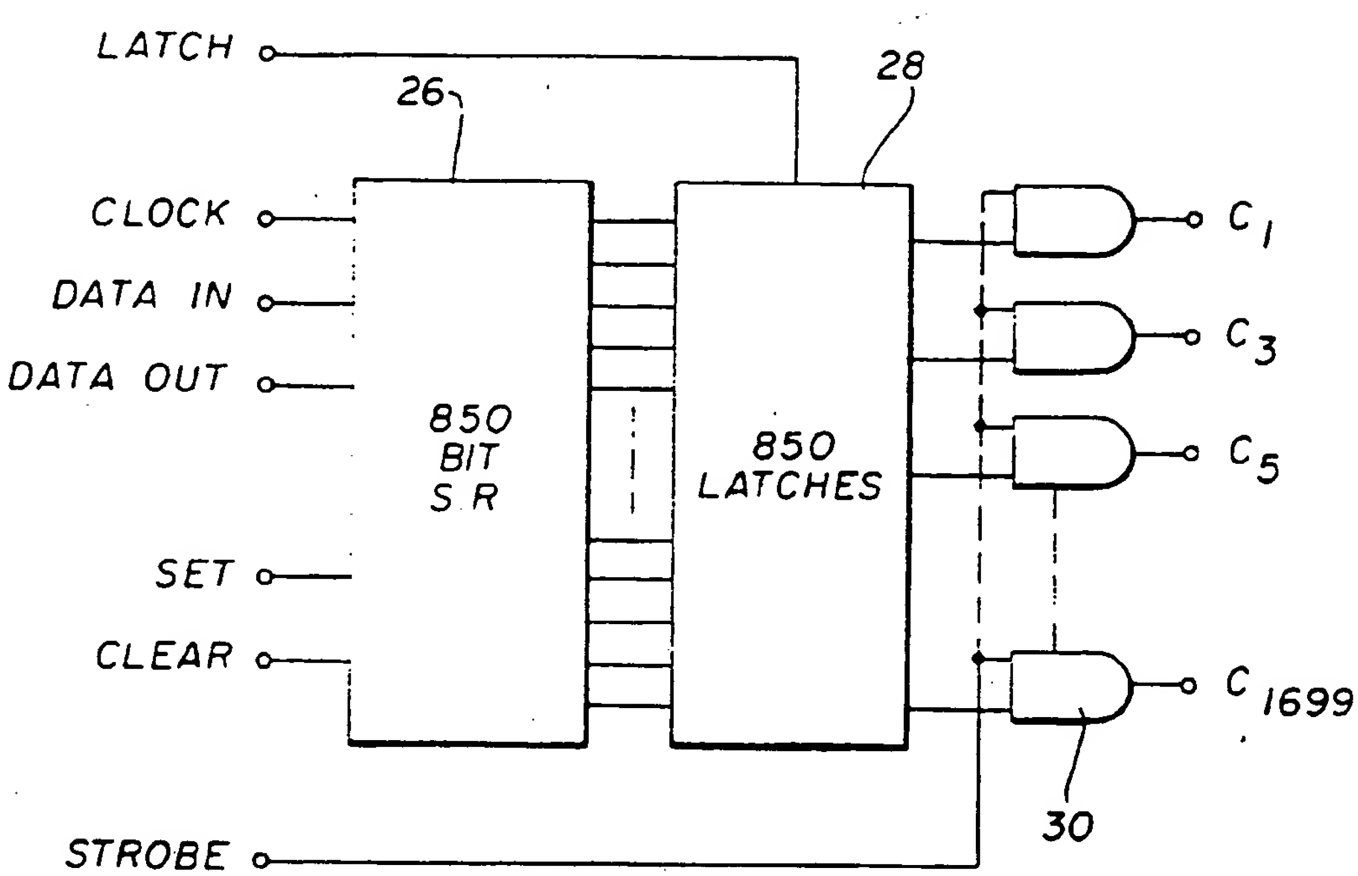

LATCH
26
28
CLOCK
DATA IN
DATA OUT
850
BIT
S.R
850
LATCHES
SET
CLEAR
STROBE
C_1
C_3
C_5
C_{1699}
30

FIG-4

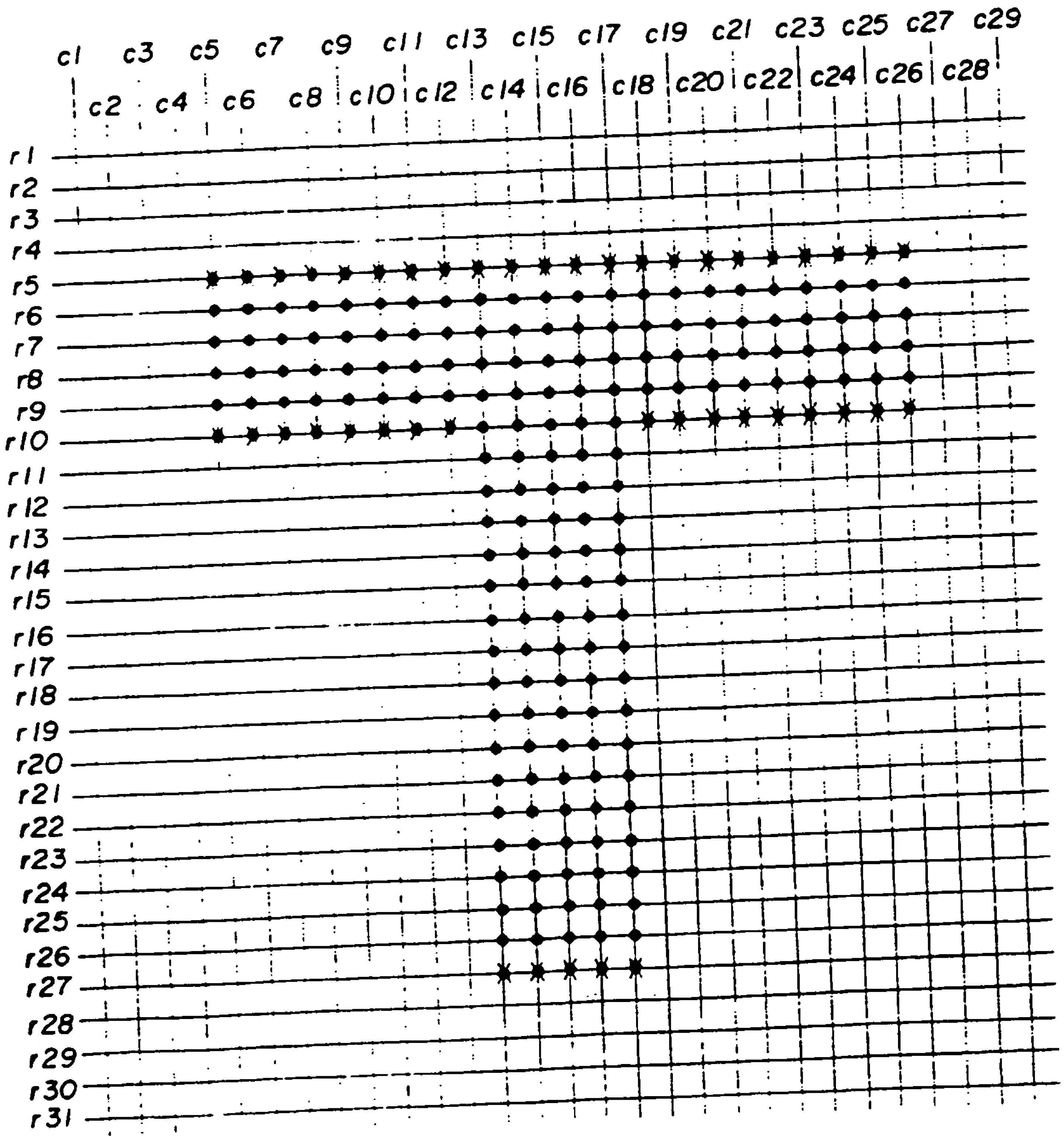
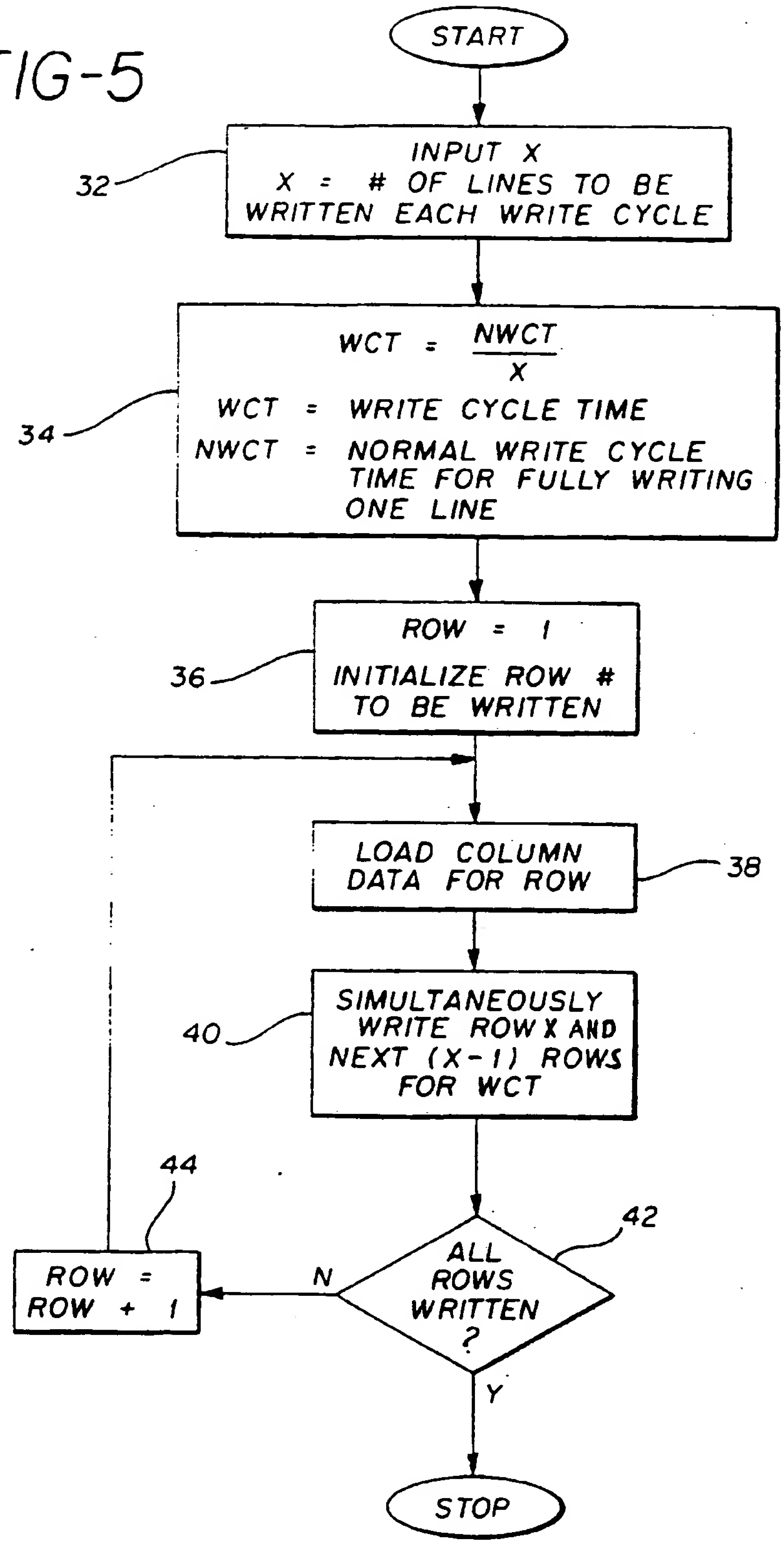

c1
c2
c3
c4
c5
c6
c7
c8
c9
c10
c11
c12
c13
c14
c15
c16
c17
c18
c19
c20
c21
c22
c23
c24
c25
c26
c27
c28
c29
r1
r2
r3
r4
r5
r6
r7
r8
r9
r10
r11
r12
r13
r14
r15
r16
r17
r18
r19
r20
r21
r22
r23
r24
r25
r26
r27
r28
r29
r30
r31

FIG-5


START
INPUT X
X = # OF LINES TO BE WRITTEN EACH WRITE CYCLE
32
WCT = NWCT / X
WCT = WRITE CYCLE TIME
NWCT = NORMAL WRITE CYCLE TIME FOR FULLY WRITING ONE LINE
34
ROW = 1
INITIALIZE ROW # TO BE WRITTEN
36
LOAD COLUMN DATA FOR ROW
38
SIMULTANEOUSLY WRITE ROW X AND NEXT (X-1) ROWS FOR WCT
40
ALL ROWS WRITTEN ?
42
N
Y
ROW = ROW + 1
44
STOP

B18

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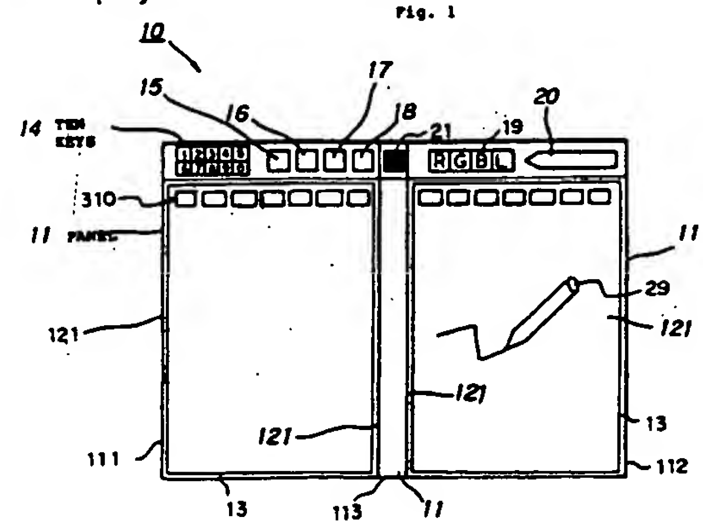
(54) ELECTRONIC NOTEPAD.

(57) An electronic notepad which has a plurality of panels (11) connected together at one side of each thereof so that the panels can be spread freely, a display means (12) provided with sheet type displays arranged on the surfaces of the panels to show images, a memory (24) for storing data to be displayed by the display means (12), sensors (13) for detecting the positions in which data is input on the display by handwriting, and a write control means (31) adapted to send a signal for setting the picture elements in the writing positions, which were detected by the sensors (13), on the displays on the panels in a predetermined displaying state, and show the picture elements in a displaying state on the displays.

Fig. 1



EP 0 618 715 A1

TECHNICAL FIELD

This invention relates to an electronic notebook which is capable of handling data of documents, drawings, etc., as usual notebooks and is very useful for achieving a paperless office.

TECHNICAL BACKGROUND

In recent years, personal computers, word processors, electronic pocketbooks, etc., have become popular as electronic machines for inputting, recording, and outputting documents, drawings, or the like without using paper or writing tools. However, with the electronic machines, usually data is input with key switches, etc., and displayed on a single screen for output.

Thus, the electronic machines do not enable anybody to easily write (input) data whenever necessary or see the contents written (recorded) on a plurality of pages at a time while comparing them. From this point of view, the electric machines are inferior to usual notebooks, books, etc., in convenience. For this reason, at offices where electronic machines as mentioned above are introduced, in fact, the contents output by the electronic machines are printed out on paper for reference or the electronic machines and paper notebooks, ledgers, etc., are used together for business processing.

Electronic pictures or illustrated books using floppy disk as media are also now on the market. However, they are hard to handle or have a narrow display range and have not become popular; in actual fact, books using normal paper are still published in large quantities.

Therefore, although the electronic machines as described above have been developed and have become widely popular, the amount of paper consumed has not decreased. In fact, it has increased because printout paper is thrown away. As a result, an acute social problem arises from the viewpoints of garbage processing and resource protection.

DISCLOSURE OF INVENTION

It is therefore, an object of the invention to provide an electronic notebook which enables anybody to easily write whenever necessary and see the wide range of recorded contents while comparing them in a sense of turning over leaves like a notebook or a book with paper pages.

To these ends, according to one form of the invention, there is provided an electronic notebook comprising:

a plurality of panels bound on one side so that they can be spread;

a plurality of display means having a thin-plate-like display disposed on a spread face of each of the panels for displaying an image on the display;

a memory for storing data for display by the display means;

a sensor for detecting a write position of a handwriting operation onto a screen displayed on the display; and

write control means responsive to the write position detected by the sensor for sending a signal, to place a picture element at the write position on the display where the writing has been made in a predetermined display state, to the display means for displaying a write state.

The memory can be provided with a storage area corresponding to the display of each of the panels. Image data written by write operation on each panel can be stored in the corresponding area of the memory.

The memory can further have a document data storage area.

The electronic notebook of the invention can further include display control means for controlling so that document data and image data stored in the memory and to be displayed on the same page are displayed on the same display.

The sensor can have pressure-sensitive sensors for detecting a pressing action and the pressure-sensitive sensors can have pressure-sensitive points disposed like a matrix on the display. Of course, the sensor can consist of magnetism detection sensors, for example.

As the sensor, a sensor such as a touch sensor for detecting an entry with a dummy pen in response to touch or contact pressure or a magnetic sensor for detecting an entry in response to magnetism can be used. With the touch sensor, any tool with a sharp point can be used as the dummy pen. With the magnetic sensor, a tool which generates predetermined magnetism from its tip may be used as the dummy pen

In the electronic notebook of the invention, an area for menu selection can be displayed in a part of the display of each panel.

The electronic notebook of the invention can further include rewrite means for converting image data representing a handwritten character into code data and storing the code data in the memory as document data.

The rewrite means can erase the image data converted into the code data and send the code data to the display means for displaying it.

The electronic notebook of the invention can further include page specification means operatively installed in a part of at least any one of the plurality of panels for accepting specification of a page to be displayed on the display.

The display control means can select the page specified with the page specification means from among the document data stored in the memory

and send it to the display means for displaying on the corresponding display.

The page specification means can further include a page feed switch for instructing pages of document data displayed on the plurality of display means to be shifted to contiguous display means one page at a time in sequence for displaying.

According to the electronic notebook of the invention, the user can draw characters, etc., by directing a writing tool such as the dummy pen toward the screen surface of the display and using it like a normal pen. The sensor detects the write trace and outputs a detection signal. When receiving the detection signal of the sensor, the write control means places the picture element corresponding to the write detection position by the sensor on the display screen in a predetermined display state. Thus, the user can draw characters or graphics, etc., as desired on the display disposed on the surface of each panel as if he or she drew characters on paper with a pencil or the like.

Moreover, since a plurality of the panels each formed with the display are bound so that they can be spread, the user can see the display contents on each screen in comparison, similarly to turning over the leaves of a notebook or book, and can also write onto the spread screen whenever necessary.

That is, if the user specifies the screen to be referenced or written with the page specification means, the display control means can display the contents of the specified page on the screen of a given panel for the user to see it.

The user can also make additional writes, corrections, underscores, etc., for the contents in the above-mentioned notebook sense; moreover, the new contents after the additional write, etc., are stored in the memory as image date related to document data.

As described above, if the rewrite means is included, handwritten characters can also be coded for storage as document data.

Therefore, the electronic notebook of the invention eliminates completely the need for using paper to prepare, record, or output documents or drawings; it can contribute greatly to promotion of paperless offices, etc.

If the external input/output means is provided, data of documents, etc., contained in external computers, etc., can be read into document storage means via the external input/output means for displaying the data on the screen. This enables the user to reference, correct, etc., the read document in the above-mentioned notebook sense. The data obtained after the correction or underscore is made can also be fed back into the computer, etc., further widening the application range.

If the electronic notebook is provided with color selection switches, the user can select display colors of characters, etc., written onto the display screen as desired; operability of the electronic notebook is further improved.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

Figure 1 is a front view of an electronic notebook according to one embodiment of the invention;

Figure 2 is a perspective view of the electronic notebook according to the embodiment of the invention;

Figure 3 is a block diagram showing the configuration of the electronic notebook according to the embodiment of the invention; and

Figure 4 is a flowchart showing the operation of the electronic notebook according to the embodiment of the invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring now to the accompanying drawings of Figures 1 to 4, there is shown one embodiment of the invention.

An electronic notebook 10 according to the embodiment of the invention has a plurality of panels 11 bound with a single shaft 11a on one side so that the electronic notebook 10 can be spread, as shown in Figure 2. In the embodiment, two of the panels 11 function as two cover panels 111 and 112 making up the cover of the electronic notebook 10 and one sandwiched between the cover panels functions as an intermediate panel 113, which can be placed over either of the cover panels 111 and 112. That is, the panels are bound so that the electronic notebook 10 can be spread. The cover panels 111 and 112 can also be put on each other with the intermediate panel between. As a result, a so-called notebook form can be made.

Although three panels are used in the example, the invention is not limited to three panels, of course. For example, the intermediate panel may be omitted or a greater number of panels can be used.

The cover panels 111 and 112 have top portions projected from the top of the intermediate panel. An external connection connector 21 serving as external input/output means for connecting to an external system is provided in a space sandwiched between the projections of the cover panels 111 and 112, namely, on the outside of the top of the intermediate panel 113.

Display and write means are provided on at least one of the two sides of each panel 11. That

is, a liquid crystal display 121 as a display like a thin plate and a touch sensor 13 for detecting a write operation on the surface of the display 121 are located on one side of each of the cover panels 111 and 112 and both sides of the intermediate panel 113.

The liquid crystal display 121 in the embodiment is capable of color display. Of course, it may be a monochrome display. The liquid crystal display 121 is one of the components of the display means 12.

In addition to the liquid crystal displays 121, the display means 12 has a code-image converter (not shown) for converting code data into image data (bit map data), a drive circuit (not shown) for driving the display 121, and video memories (not shown) for storing image data to be displayed for each panel 11.

The video memories are adapted to provide color display. In the embodiment, at least two memories are provided: One for storing code data and image data to display an instruction menu 310 and one for storing image data of handwritten input of characters, graphics, etc. The drive circuit overlays the image data stored in the video memories on each other for display on the liquid crystal display 121. Only the video memory for storing handwritten characters, etc., may be adapted to handle color display; images to display code data may be monochrome.

The touch sensor 13 consists of transparent-film pressure sensors stuck on the surface of the display 121 for detecting touch or contact in response to pressure on the surface, for example. In fact, the pressure sensors are located at a large number of detection points arranged like a matrix and senses substance contact separately. Since they are laid out like a matrix, which pressure sensor is pressed can be known. Thus, the pressed point on the screen can be detected as an address.

The pressure sensors can be laid out corresponding to display picture elements of the liquid crystal display 121, for example. On the layout of the pressure sensors, however, the pressure sensors may correspond to the display picture elements in positional relationship and they need not correspond to each other on a one-to-one basis. For example, one pressure-sensitive point may be located corresponding to a number of display picture elements.

For touch or contact with the touch sensor 13, any tool having a sharp point of predetermined thinness may be used. For example, a rod like a pen can be used. In the embodiment, a rod like a pen is provided as a dedicated writing rod, called a dummy pen. In the embodiment, the dummy pen is also used to select an entry out of the instruction menu 310 displayed on the screen and to specify the range of characters to be replaced, etc., as described below.

The cover panel 111 also has ten keys 14 as numeric keys, a page specification key 15, a page feed key 16, an auxiliary power capacity indicator 17, and a power switch 18 disposed on the top, as shown in Figure 1. The ten keys 14, the page specification key 15, and the page feed key 16 make up page specification means of the invention.

The ten keys 14 are provided to set the page number of data to be displayed on the right cover panel 112 in Figure 1. Setting the page number is not limited to the cover panel 112; the page number can be set for any desired panels. Panel selection can be made via the menu 310 displayed on the liquid crystal display 121 of each panel, for example. Unless otherwise specified, data on the setup page is displayed on the liquid crystal display 121 of the cover panel 112 as the default system configuration. Of course, for simplicity, any page numbers may be specified only for the liquid crystal display of the cover panel 112.

The page specification key 15 is provided to instruct a CPU 22 to input the page number set with the ten keys 14 as the specified page. The page feed key 16 is provided to instruct the CPU 22 to shift pages of document data displayed on display means 12 to contiguous display means 12 (for example, left in Figure 1) one page at a time in sequence.

The auxiliary power capacity indicator 17, which is provided to indicate the remaining amount of an auxiliary power supply 25 (described below), goes on when the power capacity of the auxiliary power supply 17 falls below a given value. The fact that the remaining amount is low may be indicated by an intensity change or color change.

The power switch 18 is a switch used to turn the power of the entire electronic notebook on and off.

Color selection switches 19 and a holder 20 for detachably holding a dummy pen 29 are disposed on the top of the cover panel 112. The holder 20 is provided to mount the dummy pen 29 when the pen is not used.

The color selection switches 19 are switches to specify the color of a diagram to be drawn on the liquid crystal display 121. In the embodiment, four selection switches are provided, three of which correspond to selection of R (red), G (green), B (blue), and L (light). In addition to the three primary colors, various colors produced by combining the primary colors and L (light) can be specified by selecting the switches in combination. For example, if R, L, and G are selected in order, a color produced by combining light red and dark green is selected. If G, L, B, and L are selected in order, a color produced by combining light green and light

blue is selected.

The external connection connector 21 is a connector used to transfer data to and from external machines such as personal computers and word processors.

Next, the hardware system configuration for information processing in the embodiment is described in detail with reference to Figure 3.

The information processing hardware system used in the embodiment is configured as shown in Figure 3. That is, the embodiment system comprises the central processing unit (CPU) 22 which executes processing including system control, a ROM (read-only memory) to store operation programs of the CPU 22, a RAM (random access memory) 24 serving as means for storing data, etc., the display means 12, a storage 40, an input controller 27 for controlling inputs from the switches and the touch sensor 13, an auxiliary power supply 25, a power supply 26, the auxiliary power capacity indicator 17, and the external input/output means (interface) 28.

The ROM 23 stores the programs to be executed by the CPU 22. That is, it stores various programs including programs to function as screen write control means 31, rewrite means 32, and display control means 33 which will be executed by the CPU 22. Figure 3 schematically shows the state in which the functions are provided in the CPU 22 for description. For example, a program which executes a sequence as shown in Figure 4 is contained as the program.

When receiving commands from the switches 14-16 and 19 and a detection signal from the touch sensor 13 via the input controller 27, the CPU 22 executes processing according to the programs registered in the ROM 23. For example, the CPU 22 performs processing (described below) while controlling the RAM 24, the display means 12, the external input/output means 28, etc., according to the procedure shown in Figure 4.

The display control means 33 executed by the CPU 22 reads the specified portion of various data such as document data from the RAM 24 and sends it to the display means 12 and also sends the instruction menu 310 for editing, etc., to the display means 12 for displaying it on each liquid crystal display 121.

The instruction menu 310 contains various submenus for a data input instruction from an external system, a write end instruction, write operation specification, an instruction to save written images, rewrite operation specification, etc. As the write operation specification, for example, line type, line thickness, density, erasure, copy, move, filling-in, etc., can be specified. As the rewrite operation specification, the range of characters to be replaced, the range of characters used for replacement, a character recognition execution instruction, object characters, etc., can be specified. The menu data is prestored in the RAM 24.

The menu 310 can take a hierarchical structure where when an entry is selected out of a high-ranked menu for detail specification, the corresponding low-ranked detail menu can be opened. The menu 310 may also be displayed with icons as well as characters, symbols, etc.

When receiving a signal from the touch sensor 13 input via the input controller 27, the write control means 31 determines which of the liquid crystal displays 121 the signal is input to, and which area on the display it is input to. The latter is a determination to discriminate between menu specification and handwritten input.

When it is a menu input, the write control means 31 compares the input position with menu display positions stored in the RAM 24, recognizes that the menu (entry) at the display position matching the input position is selected, and calls the program executing the command corresponding to the menu (entry).

When it is an input of handwritten characters or the like, the write control means 31 finds display picture elements based on prespecified display conditions for addresses input in sequence and sets the display density, etc., and sends them to the image data video memory of the display means 12. When receiving characters etc., the display means 12 displays on the liquid crystal display 121 of the corresponding panel 11.

When receiving a command from the write control means 31 in response to menu selection, the rewrite means 32 acknowledges a rewrite instruction, specification of the range of characters to be replaced, and specification of the range of characters used for replacement.

The rewrite means 32 also recognizes characters and further sends an object character found by character recognition to the display means 12 for displaying it at a proper position on the corresponding liquid crystal display 121, for example, on the bottom of the screen. Then, the rewrite means 32 is responsive to a selection instruction from the write control means 31 for adopting the specified object character for rewriting.

Programs, a recognition dictionary, etc., required for character recognition are prestored in the ROM 23 or the RAM 24, for example. When the programs are stored in the RAM 24, they will be loaded from the storage 40. If the RAM 24 is backed up with a battery, once the programs are loaded into the RAM 24, they need not be loaded each time the system is started.

Various instruction switches such as the ten keys 14, the page specification key 15, the page feed key 16, and the color selection switches 19

and the touch sensor 13 are connected to the input controller 27, as described above.

The external input/output means 28 has a data format conversion function as required. For example, when the data stored in the storage means 24 is image data for the display means 12 and an external machine such as a word processor to which the data is to be output handles characters, etc., with code data, the external input/output means 28 has the function of converting the image data into predetermined code data.

When the power supply 26 is turned off unexpectedly, the auxiliary power supply 25 is used to back it up for preventing data in the storage means 24, etc., from being lost.

The storage 40 can be a storage using storage media of disk type such as magnetic, optical, or magneto-optic disk. In the embodiment, it is a magnetic disk drive. The storage 40 stores various pieces of data. It may also store the programs of the CPU 22. When the power of the system is turned off, the storage 40 is also used to save the data stored in the RAM 24.

Next, the operation of the electronic notebook according to the embodiment will be described in conjunction with Figure 4.

When the power switch 18 is turned on, the CPU 22 functions as the display control means 33 for displaying the menu 310 on the top of each liquid crystal display 121. Then, the CPU 22 repeats processing at steps S1 to S12 as shown in Figure 4. The processing is described according to the steps.

At step S1, the CPU 22 functions as the write control means 31 for monitoring an input signal from the input controller 27. When a signal is input, the CPU examines the signal contents, namely, determines which liquid crystal display 121 the signal is input on and which area of the display screen it is input to. If the input signal indicates selection of a menu to specify data input from an external system, CPU control goes to step S2; otherwise, to step S4.

At step S2, the CPU 22 performs external data input processing. Input from the storage 40 or an external computer is possible as the external data input. These are selected via the menu. The external input data is stored in the RAM 24 as document data consisting of a number of pages each corresponding to the display contents of one screen of the liquid crystal display 121, and the CPU control goes to step S3. At step S3, the CPU 22 determines whether or not the external data input is completed. If it is completed, CPU control goes to step S6; otherwise, it returns to step S2.

At step S4, the CPU 22 determines whether or not page specification is made with the page specification key 15 or the page feed key 16. If the specification is made, the CPU 22 sends display data starting at the specified display page to the display means 12 according to the specification at step S4a; otherwise, it sends display data starting at the first page to the display means 12 for displaying the data at step S4b. That is, when the page specification key 15 is pressed, the contents of the page number specified with the ten keys 14 just before the key 15 is pressed (those stored in the storage means 24) are displayed on the first display, for example, the right display 121 in Figure 1.

If the page feed key 16 is pressed at this time, the displayed pages are shifted in order. In this case, if no data is registered in the storage means 24, blank pages are displayed.

At step S5, the CPU 22 functions as the write control means 31 for accepting a write with the dummy pen 29. That is, the CPU 22 determines that it is input from the touch sensor 13 of which panel. The CPU 22 also finds display picture elements based on the prespecified display conditions for addresses input in sequence and sets the display density, etc., then sends them to the image data video memory of the display means 12 and the area of the RAM 24 in which the image data on the corresponding page is stored. When receiving them, the display means 12 displays the picture elements whose input is detected by the touch sensor on the corresponding liquid crystal display in the specified display format.

Here, lines, characters, graphics, etc., can be written as desired. At this time, various functions provided at the menu, such as move, copy, delete, and filling in, can be used. The functions enable the user to, for example, make a note, write an illustration, move or copy an entry, erase the entry as if rubbing it out with an eraser, and fill in a frame of graphics.

When document data is displayed, the functions enable the user to correct, write, mark, or draw anything for the document data.

When no write representation signal remains input for a predetermined time, the CPU 22 goes to step S6a and determines whether or not page specification is made with the page specification key 15 or the page feed key 16 (step S6a). If it is made, the CPU 22 displays the specified page as at step S4a; otherwise, the CPU 22 skips step S6b and goes to step S7.

In the state, the CPU 22 checks the input controller to see if an input from the switches exists or if menu selection is made. If an input exists, the CPU 22 performs processing corresponding thereto. Here, assume that a rewrite process for converting handwritten characters into code data is requested (step S7a). The CPU 22 functions as the rewrite means 32 at step S7b. When no instruction

is given, the CPU 22 goes to step S8.

At step S7b, the CPU 22 accepts specification of the characters or area to be replaced. That is, a message is displayed on the screen requesting the user to specify the area. When the user specifies the range with the dummy pen, a similar message is displayed on the screen requesting the user to specify the range of handwritten characters to be replaced.

When the range of the handwritten characters to be replaced is specified, the CPU 22 executes character recognition for the handwritten characters in the specified range. Well known methods can be used for the character recognition method. For example, in one of the methods, the handwritten character pattern is compared with character pattern data stored in a provided recognition dictionary and when the most accurately matched pattern is found, the handwritten character is recognized as the character of the pattern.

When object characters are obtained, the CPU 22 displays them on the bottom of the screen of the corresponding liquid crystal display 121. When the user selects any of the objects with the dummy pen 29, the CPU 22 defines the object as the formal character or character string after rewrite. Now, the handwritten characters have been converted into code.

When document data is already displayed on the screen, the character or character string replaces the character or character string of the document data contained in the prespecified area. When the user selects character insertion from the menu, a newly recognized character or character string is inserted into the character string instead of replacement.

When the handwritten characters have been processed as described above, they are erased from the screen.

If no document data is displayed, when rewrite process is performed, a newly recognized character or character string is written into the blank portion in the specified range. This means that a new document is prepared.

The recognized character data is stored in the document data file stored in the RAM 24 as a part of character string.

Next, the CPU 22 checks whether or not the input operation of characters, etc., terminates by seeing if an end instruction in the menu 310 is selected at step S8. If no end instruction is given, the CPU 22 returns to step S5 and repeats the steps described above until an end instruction is input.

If the end instruction is given, then the CPU 22 determines whether or not prepared document data, image data, etc., is to be saved at step S9a. For this purpose, an inquiry message is displayed on the screen requesting the user to specify whether or not the data is to be saved. If the user selects save from the menu, the document data and image data are related to each other, then stored in the storage 40 at step S9b. That is, they are saved with information of document data pages where the image data is to be displayed.

Next, after the data is saved or after the user responds to the inquiry message with NO, the CPU 22 checks whether or not data is to be output to an external system at step S10. To do this, the CPU 22 displays a message on the screen requesting the user to specify whether or not data is to be externally output, and waits for the user to respond to the message with selection from the menu 310. In this case, a computer, word processor, or the like is possible as the external device. If data is to be externally output, the CPU 22 performs data transmission processing at step S11 and continues it until completion at step S12.

When the data transmission processing is completed or no transfer processing is performed, the operation of the embodiment system terminates. In this state, control returns to the initial menu screen.

At handwriting input, input line color can be specified by using the color selection switches 19.

In the embodiment, document data is input and edited and handwriting is made into the document data as an example, but image data can be input and edited, of course.

Further, in the embodiment, the liquid crystal display is shown as a display example, but the display may be any display if it is thin, and is not limited to the liquid crystal display.

Thus, according to the electronic notebook 10, if a tool having a sharp point, such as the dummy pen 29, is brought into contact with the surface of the screen of the display means 12 and characters, etc. in response to the thinness of the line to be drawn, and operated as with a normal pen, the touch sensor 13 detects the contact and in response to the detection, the CPU 22 (write control means 31) places the picture element at the pressed position on the screen of the display means 12 in a predetermined display state. Therefore, the user can draw characters, graphics, etc., as desired on the liquid crystal display 121 disposed on the surface of each panel 11 as if he or she drew them on paper with a pencil.

Moreover, a plurality of the panels 11 formed with the display means 12 are bound so that they can be spread, thus the user can see the display on each screen in comparison as if he or she turned over the leaves of a notebook or book, and can also write onto the spread screen whenever necessary.

The characters, graphics, etc., drawn on the display screen are stored in the RAM 24 by the

CPU 22. That is, data equivalent to the characters, graphics, etc., on the display screen can be stored within the range of the capacity of the RAM 24 with pages related to the data, and can be called for handling whenever necessary. If the user specifies the document page for reference or write with the page specification means 14, 15, or 16, the CPU 22 (display control means) displays the contents of the specified page on the screen of the predetermined panel 11.

The CPU 22 (rewrite means 32) executes character recognition and inserts the recognized character or character string in the specified position of the displayed document data as a new character or character string or replaces the character or character string at the specified position with the new character or character string.

Thus, according to the embodiment, the user can make document reference, additional write, correction, underscore, etc., in the above-mentioned notebook sense. Moreover, the contents of the additional write, etc., can be related to document data for storage.

Further, the external input/output means 28 enables data to be shared with external computers, word processors, etc. That is, data of documents, etc., contained in the external computers, etc., can be read into the RAM via the external input/output means 28 for displaying on the screen. Then, rather than seeing the screen at a given distance as the display of a computer or the like, the user can touch an open page like a book or notebook and write underscores with the dummy pen 29 with color specification and enter new characters or graphics for referencing or correcting the document in a notebook sense. The data obtained after the correction or underscore is made can also be fed back into the computer, etc.

Therefore, for example, to input a document such as a patent specification into a computer and check the contents, it can be read into the electronic notebook so that the user can underscore check points and important items with color such as red, blue, etc. and display a drawing on another page at the same time for taking notes while looking at the drawing. Thus, the user can handle it in the same way as if it were a printed-out specification; the electronic notebook is extremely useful.

Therefore, the electronic notebook can eliminate the need for using paper to prepare, record, or output documents or graphics; it can contribute greatly to promotion of paperless offices, etc.

Although a touch sensor for detecting touch or contact pressure is used as the touch sensor in the embodiment, the invention is not limited to it. For example, a sensor for detecting magnetism may be used, in which case a tool which generates magnetism from its tip needs to be used as the dummy pen.

Claims

1. An electronic notebook comprising:

   a plurality of panels bound on one side so that they can be spread;

   a plurality of display means having a thin-plate-like display disposed on a spread face of each of said panels for displaying an image on said display;

   a memory for storing data for display by said display means;

   a sensor for detecting a write position of a handwriting operation onto a screen displayed on said display; and

   write control means responsive to the write position detected by said sensor for sending a signal, to place a picture element at the write position on said display where the writing has been made in a predetermined display state, to said display means for displaying a write state.

2. The electronic notebook as claimed in claim 1 wherein said memory can be provided with a storage area corresponding to the display of each of said panels and image data written by write operation on each panel is stored in the corresponding area of said memory.

3. The electronic notebook as claimed in claim 2 wherein said memory further has a document data storage area.

4. The electronic notebook as claimed in claim 3 further including display control means for controlling so that document data and image data stored in said memory and to be displayed on the same page are displayed on the same display.

5. The electronic notebook as claimed in claim 3 wherein said sensor has pressure-sensitive sensors for detecting a pressing action and said pressure-sensitive sensors have pressure-sensitive points disposed like a matrix on the display.

6. The electronic notebook as claimed in claim 5 wherein an area for menu selection is displayed on a part of the display of each panel.

7. The electronic notebook as claimed in claim 4 further including rewrite means for converting image data representing a handwritten character into code data and storing the code data in said memory as document data.

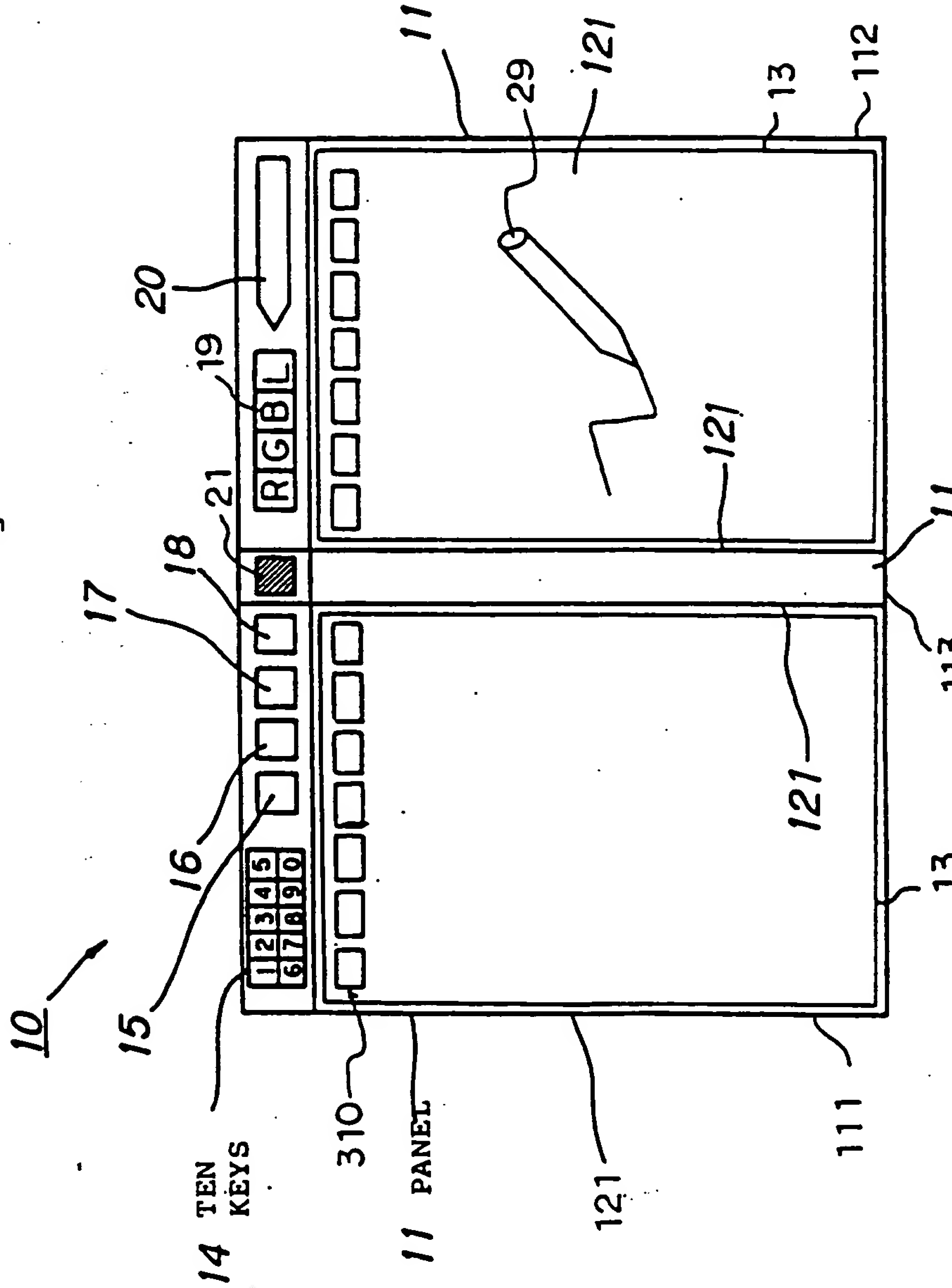
8. The electronic notebook as claimed in claim 7 wherein said rewrite means erases the image data converted into the code data and sends the code data to said display means for displaying it.

9. The electronic notebook as claimed in claim 4 further including page specification means operatively installed in a part of at least any one of said plurality of panels for accepting specification of a page to be displayed on the display.

10. The electronic notebook as claimed in claim 9 wherein said display control means selects the page specified with said page specification means from among the document data stored in said memory and sends it to said display means for displaying on the corresponding display.

11. The electronic notebook as claimed in claim 9 wherein said page specification means further includes a page feed switch for instructing pages of document data displayed on said plurality of display means to be shifted to contiguous display means one page at a time in sequence for displaying.

Fig. 1


10
14 TEN KEYS
15
16
17
18
21
19
R G B L
20
11
29
121
13
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11 PANEL
310
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11
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6 7 8 9 0

Fig. 2

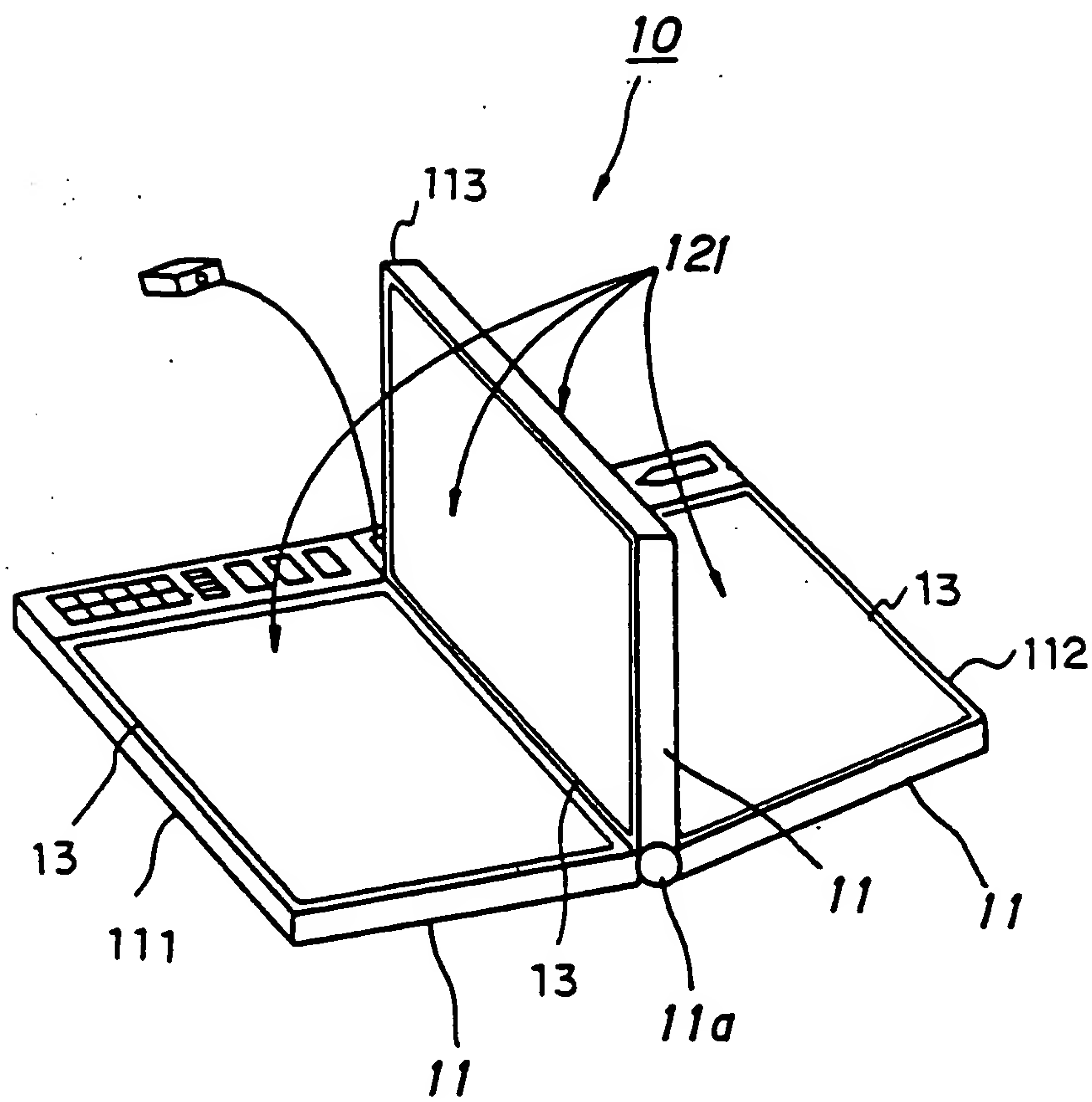
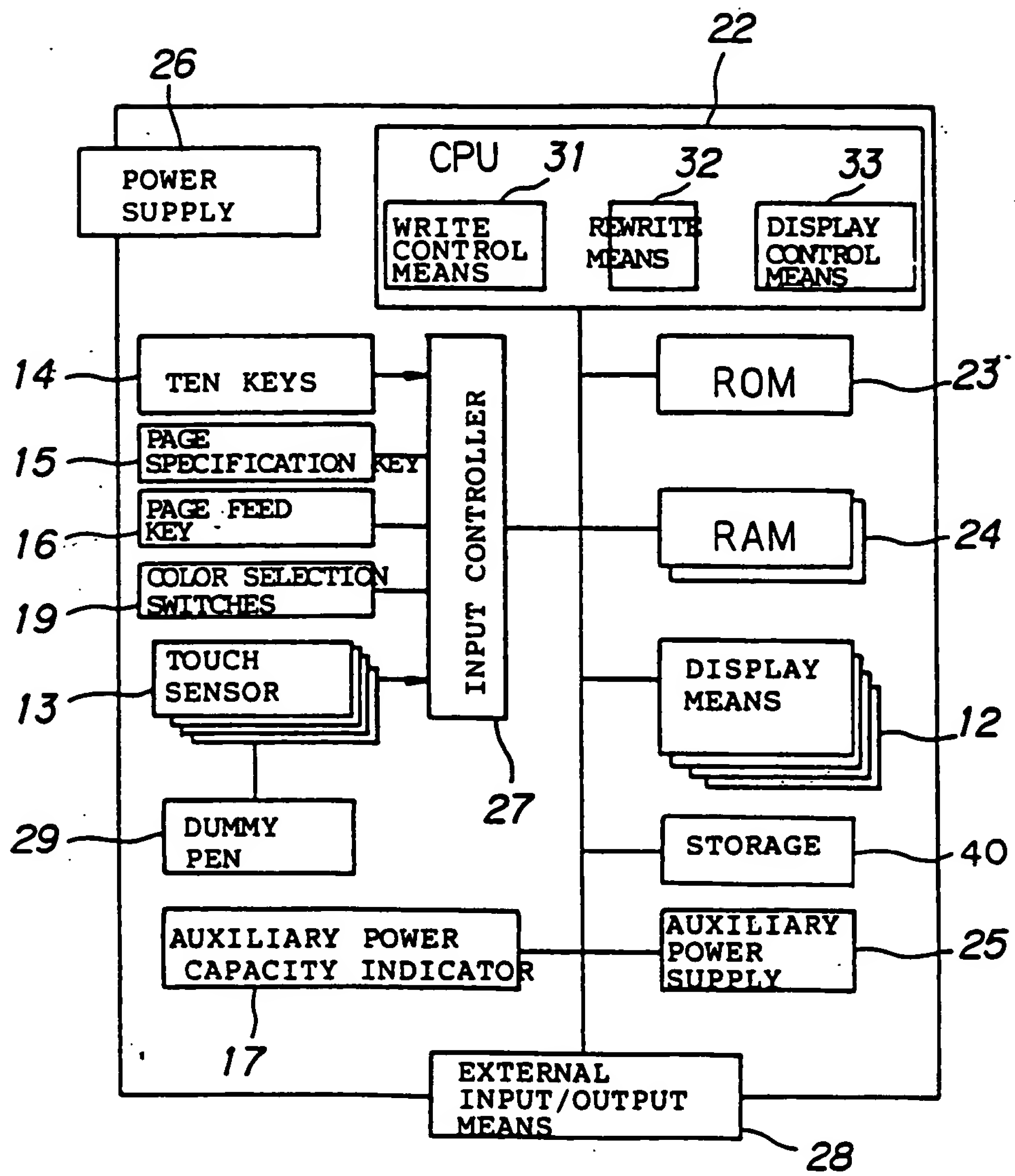
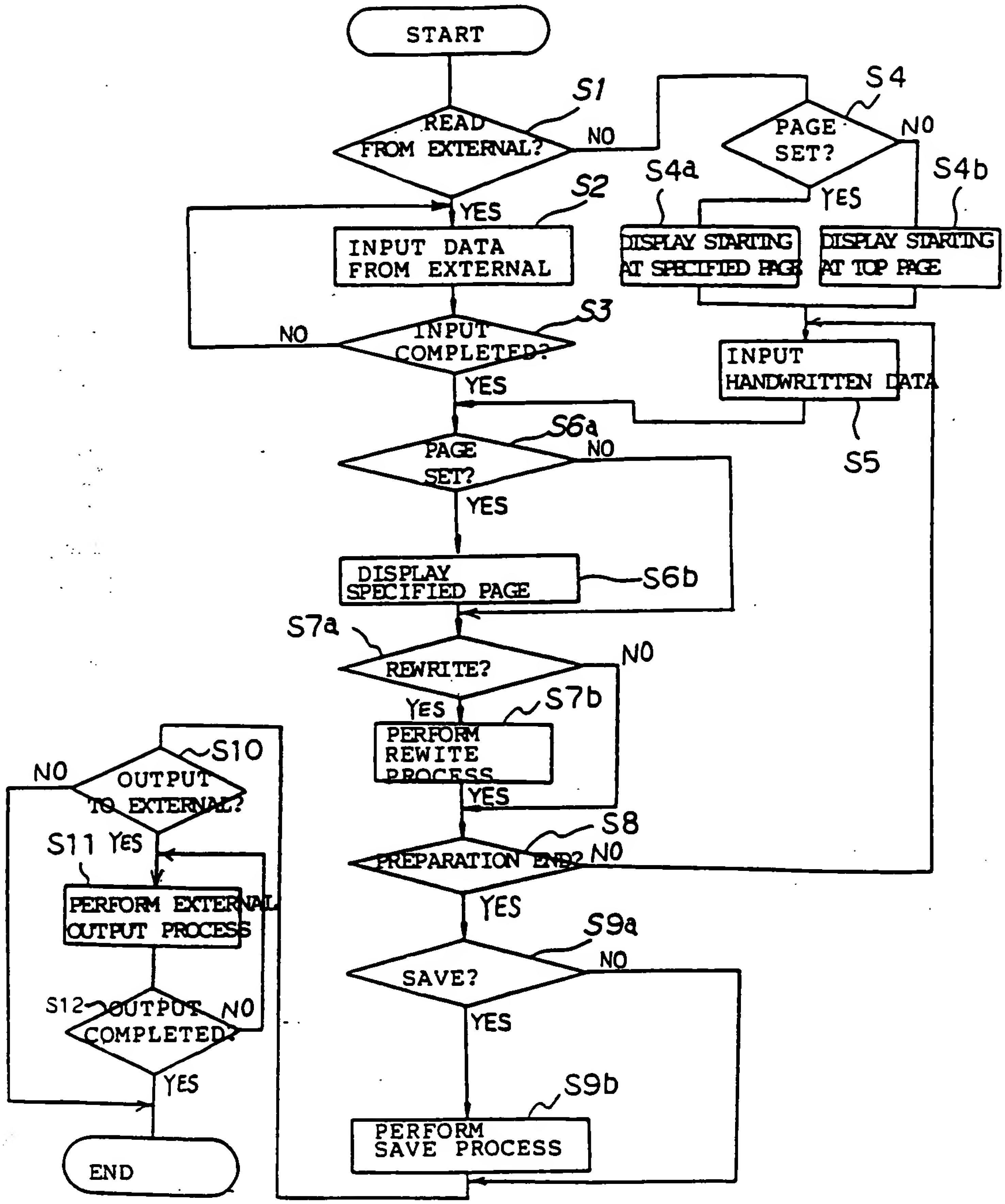


Fig. 3



22
26
POWER SUPPLY
CPU
31
32
33
WRITE CONTROL MEANS
REWRITE MEANS
DISPLAY CONTROL MEANS
14
TEN KEYS
ROM
23
15
PAGE SPECIFICATION KEY
INPUT CONTROLLER
16
PAGE FEED KEY
RAM
24
19
COLOR SELECTION SWITCHES
13
TOUCH SENSOR
DISPLAY MEANS
12
29
DUMMY PEN
27
STORAGE
40
AUXILIARY POWER CAPACITY INDICATOR
AUXILIARY POWER SUPPLY
25
17
EXTERNAL INPUT/OUTPUT MEANS
28

Fig. 4


START
S1
READ FROM EXTERNAL?
NO
YES
S2
INPUT DATA FROM EXTERNAL
S3
INPUT COMPLETED?
NO
YES
S4
PAGE SET?
NO
YES
S4a
DISPLAY STARTING AT SPECIFIED PAGE
S4b
DISPLAY STARTING AT TOP PAGE
INPUT HANDWRITTEN DATA
S5
S6a
PAGE SET?
NO
YES
DISPLAY SPECIFIED PAGE
S6b
S7a
REWRITE?
NO
YES
S7b
PERFORM REWITE PROCESS
YES
S8
PREPARATION END?
NO
YES
S9a
SAVE?
NO
YES
S9b
PERFORM SAVE PROCESS
S10
OUTPUT TO EXTERNAL?
NO
S11
YES
PERFORM EXTERNAL OUTPUT PROCESS
S12
OUTPUT COMPLETED?
NO
YES
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP92/01623

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl^5 H04N1/00, G06F3/033

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl^5 H04N1/00, G06F3/033, G06F3/03, G06F15/40

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1926 - 1992
Kokai Jitsuyo Shinan Koho 1971 - 1992

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP, A, 62-271122 (Ricoh Co., Ltd.), November 25, 1987 (25. 11. 87), (Family: none)	1, 2 3-11
Y	JP, A, 61-259337 (Matsushita Electric Ind. Co., Ltd.), November 17, 1986 (17. 11. 86), (Family: none)	3, 4, 7-11
Y	JP, A, 2-300918 (Seiko Epson Corp.), December 13, 1990 (13. 12. 90), (Family: none)	5-7
Y	JP, A, 63-8866 (Toshiba Corp.), January 14, 1988 (14. 01. 88), (Family: none)	11

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
January 13, 1993 (13. 01. 93)	February 9, 1993 (09. 02. 93)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

819

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⑤④ **Touchpad.**

⑤⑦ A touchpad using a dual sensor comprising two touchpad sensors having different resolutions being sandwiched to form a single sensor. The two touchpad sensors are configured and positioned such that a single touch of a finger, stylus, or the like is capable of being detected by both sensors. The dual sensor is capable of being scanned more quickly than single sensors and is capable of being interfaced by significantly fewer drivers and receivers.

In one embodiment, the touchpads to be sandwiched to form the dual sensor comprise a first plurality of electrically conductive strips positioned proximate to a second plurality of electrically conductive strips. The conductive strips in each plurality lie substantially in a single plane and the two pluralities are skewed relative to one-another in plan view. Ideally, the pluralities are aligned orthogonally. The conductive strips are separated by insulators that extend beyond the surface of the conductors to separate the conductors of one plurality from the conductors of the other plurality until a localized pressure is applied to a region of the pad.

Two such sensors are sandwiched to form an embodiment of the dual sensor of the present invention. When a localized pressure is applied, the conductors and insulators of both sensors deform until a conductor from the first plurality forms an electrically conducting path with at least one conductor from the second plurality.

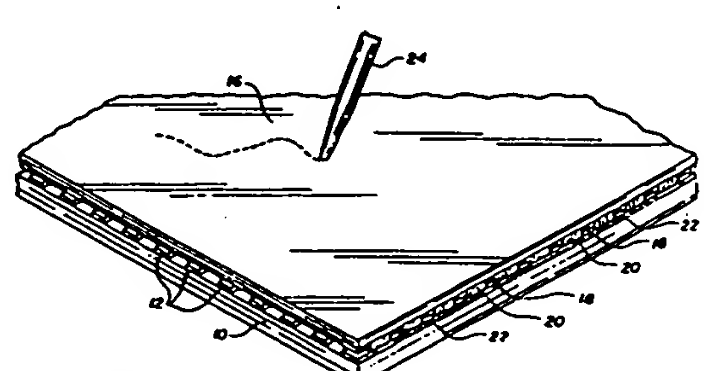

FIG. 1A

EP 0 684 579 A2

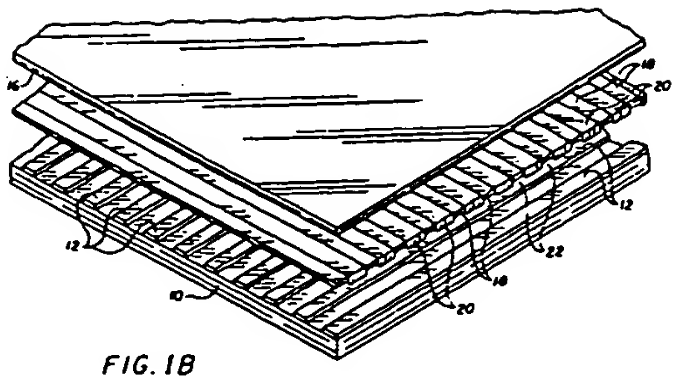

FIG. 1B

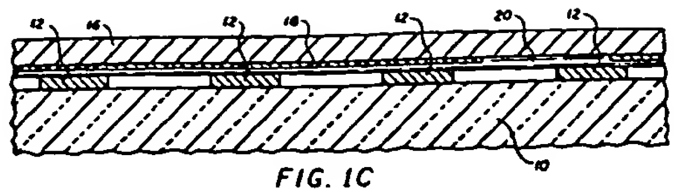

FIG. 1C

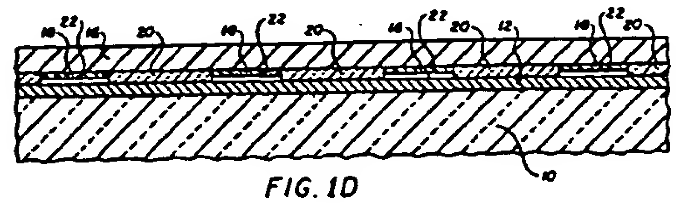

FIG. 1D

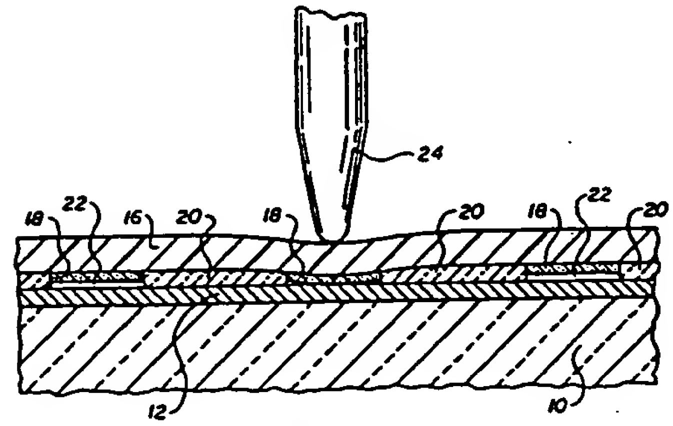

FIG. 1E

The present invention relates generally to input devices for digital electronic systems.

Touchpads, also known as digital pads, are coordinate type pointing devices used to input coordinate type data to computer systems and computer-controlled devices. A touchpad is typically a pressure-sensitive bounded plane capable of detecting localized pressure at its surface. When a user touches the surface with a finger, stylus, or the like, the circuitry associated with the touchpad determines and reports to the attached computer system the coordinates of the location touched. In response, the computer performs the function, if any, associated with the location pressed.

Typically one or more regions of the touchpad are assigned to certain functions within the system. The user is made aware of what function is associated with each region by a template. A template is a sheet with a graphic design and is typically placed over and in contact with the touchpad surface. The graphic design typically maps out regions of the touchpad surface and the regions are typically labeled to provide a reminder to the user as to the functions associated with the various mapped regions.

A touchpad's sensor is the heart of the touchpad. Several types of touchpad sensors are known in the art, such as switch closure type sensors. For example, a keyboard sensor having matrix of membrane switches is disclosed in U.S. Patent No. 4,736,190 to Florella. A touch by a finger on a key causes a closure event between a pair of conductors. As with other switch closure type sensors, the location of the touch is detected using a bank of digital signal drivers and a bank of digital signal receivers.

Other devices known in the art are very complex. For example, U.S. Patent No. 4,529,959 to Ito et al. discloses a sensor for a coordinate type input device comprising a braided lattice of conductors embedded in a compressible open-cell insulating material sandwiched between two insulating layers coated with a resistive material. Another sensor is shown in U.S. Patent No. 4,455,450 to Margolin. This sensor involves resistive sheets sealed into a "pillow" form.

Typically one digital signal driver per row and one digital signal receiver per column is used. In high-resolution devices, the large number of drivers required significantly adds to the cost of the scanning electronics and, therefore, the cost of the touchpad. For example, a touchpad that is 640 rows by 480 columns will require 480 drivers and 640 receivers for a total of 1120 (640 + 480 = 1120) individual device pins. An electrical device having 1120 pins can be prohibitively expensive using programmable logic devices (PLDs) or even an application specific integrated circuit (ASIC).

In addition, high-density devices can have a relatively slow response time because each driver is sequentially activated and each receiver must be checked for each driver. A matrix that is 640 rows by 480 columns can require as many as 307,200 individual scans, because each row is sequentially driven by the drivers and each column must be scanned for each driven row.

It is therefore desirable to provide a high-resolution touchpad sensor without the need for a correspondingly large number of drivers and receivers.

It is also desirable to provide a touchpad sensor suitable for simplified scanning with a corresponding increase in the scanning bandwidth.

In accordance with the present invention, there is now provided a dual sensor comprising: a first touchpad sensor having a first resolution; and a second touchpad sensor substantially the same size as said first touchpad sensor, having a second resolution, and positioned proximate to said first touchpad sensor; wherein said first touchpad resolution is different from said second touchpad resolution; and wherein said first and second touchpad sensors are configured and positioned such that a single touch of a finger, stylus, or the like is detectable by both said first touchpad sensor and said second touchpad sensor.

Viewing the present invention from another aspect, there is now provided a method of fabricating a touchpad sensor comprising the steps of: (a) affixing a first plurality of conductors onto a first substrate; (b) affixing a second plurality of conductors onto the first side of a second substrate; (c) affixing a first plurality of insulators onto the first side of said second substrate; (d) affixing a third plurality of conductors onto the second side of said second substrate; (e) affixing a second plurality of insulators onto the second side of said second substrate; (f) affixing a fourth plurality of conductors onto a third substrate; and (g) positioning said first, second, and third substrates such that said insulators of said first plurality of insulators are in physical contact with said first plurality of conductors, said insulators of said second plurality of insulators are in physical contact with said fourth plurality of conductors, said insulators of said first plurality of insulators prevent physical contact between said conductors of said first and second pluralities of conductors until a localized pressure is applied, said insulators of said second plurality of insulators prevent physical contact between said conductors of said third and fourth pluralities of conductors until a localized pressure is applied, said first and second pluralities of conductors are skewed in plan view, said third and fourth pluralities of conductors are skewed in plan view.

Viewing the present invention from still another aspect, there is now provided a dual sensor comprising: a first plurality of conductors that are flexible, spaced from adjacent conductors by a first plurality of insulators, and substantially parallel to each other; a second plurality of conductors proximate to said first plurality of conductors, substantially parallel to each other, skewed with respect to said first plurality of conductors in plan view, and spaced from adjacent conductors of said second plurality of conductors by a second plurality of insulators; a stylus surface proximate to said first plurality of conductors for accepting pressure from a finger, a stylus, or the like; a third plurality of conductors that are flexible, positioned proximate to said first plurality of conductors, spaced from adjacent conductors by a third plurality of insulators, and substantially parallel to each other; and a fourth plurality of conductors proximate to said third plurality of conductors, substantially parallel to each other, skewed with respect to said third plurality of conductors in plan view, and spaced from adjacent conductors of said fourth plurality of conductors by a fourth plurality of insulators; wherein each of said conductors of said first and second pluralities of conductors and each of said insulators of said first and second pluralities of insulators is configured and positioned such that each of said first plurality of conductors has two states: a relaxed state and a flexed state; said relaxed state being characterized by said conductor not being in electrically conducting contact with any of said conductors of said second plurality of conductors; and said flexed state being characterized by said conductor being in electrically conducting contact with at least one conductor of said second plurality of conductors; wherein each of said conductors of said first and second pluralities of conductors and each of said insulators of said first and second pluralities of insulators is further configured such that the asserting a predetermined amount of pressure from a finger, stylus, or the like to said stylus surface causes at least one of said first plurality of conductors in said relaxed state to enter said flexed state and removing the predetermined amount of pressure from said stylus surface causes said at least one of said conductors in said flexed state to enter said relaxed state; wherein each of said conductors of said third and fourth pluralities of conductors and each of said insulators of said third and fourth pluralities of insulators is configured and positioned such that each of said third plurality of conductors has two states: a relaxed state and a flexed state; said relaxed state being characterized by said conductor not being in electrically conducting contact with any of said conductors of said fourth plurality of conductors; and said flexed state being characterized by said conductor being in electrically conducting contact with at least one conductor of said fourth plurality of conductors; and each of said conductors of said third and fourth pluralities of conductors and each of said insulators of said third and fourth pluralities of insulators is further configured such that the asserting a predetermined amount of pressure from a finger, stylus, or the like to said stylus surface causes at least one of said third plurality of conductors in said relaxed state to enter said flexed state and removing the predetermined amount of pressure from said stylus surface causes said at least one of said conductors in said flexed state to enter said relaxed state.

In a preferred embodiment of the present invention, a touchpad sensor is provided having two integrated sensors: a low- resolution sensor and a high-resolution sensor. The two sensors are positioned such that they overlap and such that applying pressure with a finger, stylus, or the like causes two events: a detection event at the first sensor and a detection event at the second sensor.

In one arrangement of the dual sensor of the present invention, the sensors have a first plurality of electrically conductive strips positioned proximate to a second plurality of electrically conductive strips. The conductive strips in each plurality lie substantially in a single plane and the two pluralities are skewed relative to one-another when viewed from the top. Ideally, the pluralities are aligned orthogonally. In both pluralities, the conductive strips are separated by insulating strips that extend beyond the surface of the conductors to separate the conductors of one plurality from the conductors of the other plurality until a localized pressure is applied to a region of the pad. When a localized pressure is applied, the conductors and insulators deform until a conductor from the first plurality forms an electrically conducting path with at least one conductor from the second plurality.

In a dual sensor arrangement of the present invention, two of the sensors described above, one of which has wide conductors and the other of which has narrow conductors, are sandwiched in overlapping relationship to form a dual sensor with first, second, third, and fourth pluralities of conductors. The wide conductors are relatively few in number as compared to the narrow conductors. When a localized pressure is applied, the conductors and insulators deform until a conductor from the first plurality forms an electrically conducting path with at least one conductor from the second plurality and a conductor from the third plurality forms an electrically conducting path with at least one conductor from the fourth plurality.

This dual sensor greatly simplifies the scanning process. First, the wide conductors are scanned using drivers and receivers. Locating the position of

the touch at the intersection of the wide row and wide column provides the position of the touch to within a rectangular area the size of one wide conductor. To determine the location of the touch to the accuracy of the narrow conductors, all the narrow conductors need not be scanned. Only the narrow conductors corresponding to that intersection need be scanned. Thus, the scanning process is simplified by significantly reducing the number of narrow conductors to be scanned; the number of narrow conductors to be scanned has been reduced to the number covered by the intersection of the wide conductors. Thus, the number of narrow scan drivers and receivers are reduced by the ratio of narrow conductors to wide conductors. Hundreds of driver scans can be avoided, thereby avoiding hundreds of thousands of overall scans. Thus, the time-savings associated with the dual sensor scan of the present invention can be quite significant.

The dual sensor embodiment described above is not overly complex and can be manufactured using standard lithography techniques and relatively inexpensive materials. Standard driver-receiver banks can be used to scan the touchpad sensor and detect the location of the touch.

This dual sensor concept can also be applied to sensors of different technologies, such as the devices mentioned in the Background, above. The dual sensor simplifies the scanning process regardless of the technology of the two sensors involved.

It is therefore an advantage of the present invention to provide a dual sensor that greatly simplifies and speeds up the scanning process by significantly reducing the number of drivers and receivers needed.

It is a further advantage of this invention to provide a dual sensor that greatly reduces the cost of the scanner needed to determine the location of the touch by significantly reducing the number of drivers and receivers needed.

These and other advantages of the present invention will become more apparent from a detailed description of the invention.

A preferred embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1A is a perspective view of one embodiment of a single touchpad sensor, two of which form one embodiment of the dual sensor of the present invention;

Figure 1B is an exploded perspective view of the single sensor shown in Figure 1A;

Figure 1C is a front elevational view of the single sensor shown in Figure 1A with parts broken away for clarity;

Figure 1D is a side elevational view of the single sensor shown in Figure 1A with parts broken away for clarity;

Figure 1E shows the effects of pressure from a stylus on the sensor shown in Figure 1D;

Figure 2A is a perspective view of an embodiment of the dual sensor of the present invention;

Figure 2B is an exploded perspective view of the embodiment of the present invention shown in Figure 2A;

Figure 2C is a front elevational view of the embodiment shown in Figure 2A with parts broken away for clarity;

Figure 2D is a side elevational view of the embodiment shown in Figure 2A with parts broken away for clarity;

Figure 2E shows the effects of pressure from a stylus on the embodiment of the present invention shown in Figure 2C;

Figure 3A is a front elevational view of another embodiment of the single sensor with parts broken away for clarity;

Figure 3B shows the effects of pressure from a stylus on the single sensor shown in Figure 3A;

Figure 4A is a front elevational view of another embodiment of the dual sensor of the present invention with parts broken away for clarity;

Figure 4B shows the effects of pressure from a stylus on the embodiment of the present invention shown in Figure 4A;

Figure 5A is an electrical block diagram showing the major components of an embodiment of an electrical circuit for interfacing to the touchpad sensor shown in Figures 1A-1E;

Figure 5B is an electrical schematic diagram showing an implementation of the electrical circuit for interfacing to the touchpad sensor shown in Figures 1A-1E;

Figure 5C is an electrical schematic diagram showing the details of the y-drivers for the electrical circuit for interfacing to the touchpad sensor shown in Figures 1A-1E;

Figures 5D and 5E are waveform diagrams showing the relationships between several selected signals of the circuit shown in Figures 5B and 5C;

Figure 5F is an electrical schematic diagram showing the details of the x-receivers for the electrical circuit for interfacing to the touchpad sensor shown in Figures 1A-1E;

Figure 6 is an electrical block diagram showing the major components of an embodiment of an electrical circuit for interfacing to the dual sensor shown in Figures 2A-2E;

Figure 7A is a top view of one layer of conductors of yet another embodiment of the touchpad sensor;

Figure 7B is a top view of the embodiment of the sensor shown partially in Figure 7A;

Figure 7C is a side elevational view of the embodiment shown in Figure 7B taken along the line 7C-7C; and

Figure 8 is a side elevational view of the construction of the embodiment shown in Figures 1A-1E with the integrated circuits embodying the circuitry of Figures 5A-5F.

Referring now to the drawings and for the present to Figures 1A-1E, one embodiment of a touchpad sensor is shown. This embodiment includes a first plurality of non-intersecting longitudinally extending spaced conductors formed on a first substrate, and a second plurality of non-intersecting conductors longitudinally extending on a second flexible substrate, separated by strips of resilient insulating material. The substrates are arranged to support the conductors in superposed spaced relationship, and with the first and second sets of conductors being positioned to extend skewed and preferably orthogonally with respect to each other and maintained by the insulating strips normally spaced from each other. With this configuration, pressure exerted upon the flexible substrate overcomes the resilience of the resilient insulating strips and which, together with the flexibility of the substrate and insulating strips, allows the portions of the first and second conductors at the location of the pressure to come into electrical contact with each other. This location of contact is defined in an X-Y axis on the planes of the conductors and can be translated by circuitry to be explained presently to a signal corresponding to the location of the pressure on the touchpad.

Specifically in this embodiment, a relatively rigid substrate 10 is provided which preferably is formed of glass-filled epoxy such as an epoxy circuit board material known as FR4. Typically, this board is about 2 mm thick, although other insulating materials of various thickness can be used. A plurality of spaced non-intersecting longitudinally extending x-conductors 12 are formed on the substrate 10. These x-conductors preferably are substantially equal in spacing and width and are preferably formed of copper with a Gold flash using conventional printed circuit board fabrication photoresist techniques. Either positive or negative photoresist may be used, and either additive or subtractive plating may be used, which techniques are well known in the art. One particularly desirable technique is to start with a substrate having 1 oz. copper plated thereon, and by lithographic technique expose and develop the photoresist and etch the revealed copper to form the desired conduction pattern under the remaining resist. This resist is then removed and the copper plated up to the desired structure--normally .036 mm. A Gold flash is then provided on the copper for oxidation resistance. This technique is well known in the printed circuit board industry. Thus, a plurality of longitudinally extending spaced x-conductors 12 are formed on the substrate 10. Of course, other techniques and materials such as screen printing of conductive inks could be used.

The touchpad also includes a flexible membrane 16 which preferably is formed of a polyester such as that sold by International Chemical Industries (ICI) of Great Britain or hard coated polyester sold by the E.I. du Pont Company. The preferred material is ICI Melinex ST525, which is manufactured by ICI Films, Wilton Centre, PO Box 90, Middlesbrough, Cleveland, TS90 8JE, United Kingdom. A hardened version of the ST525 is preferred and available from Cadillac Plastics, Rivermead Road, Westlea, Swindon, Wiltshire, United Kingdom. Membrane thicknesses of 0.003 inch and 0.005 inch have proved to be effective.

Deposited on the flexible membrane 16 are a plurality of non-intersecting y-conductors 18 which extend longitudinally thereon. In Figure 1C, certain parts, including a portion of the y-conductor 18, have been partially cut away for clarity. The y-conductors 18 preferably are substantially equal in spacing and width and are preferably formed by printing with conductive ink using conventional mask printing techniques and conventional conducting inks such as epoxies with silver particles contained therein. One suitable screen printable conductive ink is available from Acheson Colloids, Prince Rock, Plymouth, Devon, United Kingdom.

Between the y-conductors 18 are strips of resilient insulating material 20. The strips of insulating material 20 are preferably Acheson ML25227, which is manufactured by Acheson Colloids, Prince Rock, Plymouth, Devon, United Kingdom, and available from NFI Electronics Ltd., Dodnor Industrial Estate, Newport, Isle of Wight, PO30 5XB, England. However, any material that is easily printed or applied in fine strips and that has sufficient flexibility (15,000 cycles measured under ASTM D2176 is sufficient), dielectric strength (125 KV/mm measured under ASTM D149 is sufficient), and surface resistivity (10^{13} ohms/square measured under ASTM D257 is sufficient) can be used to make the insulating strips 20. The insulating strips 20 are applied using conventional screen printing techniques, as known to those skilled in the art.

The thickness of the y-conductors 18 preferably is about 12 micrometers, and the thickness of the resilient insulating strips 20 is approximately 22 micrometers. Therefore, the insulating strips 20 extend about 10 micrometers below the conductors 18. Consequently, when the insulators 20 are placed in contact with the conductors 12, as will be discussed presently, the conductors 12 are separated from the conductors 18 by approximately 10 micrometers.

In the figures, the edges of the conductors 18 are touching the edges of the insulators 20. This is an ideal condition. In practice, the printing mask for the insulators is slightly narrower than the spaces between the conductors 18. Therefore, when the insulating material is applied, a small gap exists between the insulator 20 and the adjacent conductor 18. The width of the gap (not shown) is not critical; it should be such that when the insulating material is applied and it spreads, no portion of the conductor is covered by the insulating material.

Also in the figures, each conductor 18 has an insulating strip 20 on either side of it. In the alternative, fewer insulating strips 20 might be sufficient to keep the conductors 12, 18 from contacting and causing an electrical short circuit. For example, every second or every second and third insulating strip 20 might be replaced with an air gap (not shown) between the conductors 18, in the manner the conductors 12 are separated from each other, as will be explained below.

As can best be seen in Figures 1B, 1C, and 1D, the substrate 10 and flexible membrane 16 are placed in superposed relationship with each other, with the conductors 12 and 18 facing each other and with the conductors 12 and 18 oriented skewed and preferably orthogonally with respect to each other, and in such a position that the insulating strips 20 are in contact with the x-conductor 12 on the substrate 10. Locating pins (not shown) are formed on the substrate 20 and coact with holes (not shown) in the membrane 16 to properly align the conductors 12 and 18. With the substrates so arranged and with the insulating strips 20 in contact with x-conductors 12, the conductors 12 and 18 are separated from each other by a gap 22, as seen best in Figure 1D. The distance between the conductors 12 and 18 being about 10 micrometers since each of the resilient insulating strips 14 extend about 10 micrometers below the y-conductors 18. The 10 micrometer gap 22 normally is filled with air. However, since the interior of the touchpad is preferably sealed, as will be described presently, inert gas such as nitrogen or argon may be used, alternatively. However, normally an air gap is sufficient.

When a sufficient pressure is exerted such as by the point of a stylus 24, or a finger or the like, the flexible membrane 16 deflects as shown in Figure 1E. The resiliency of the resilient insulator strips 20 and flexibility of the membrane 16 allow for the membrane 16 to deflect until portions of the conductors 18 and 12, which are opposed to each other, come into electrical contact with each other. The tip of the stylus 24 must be sufficiently small in diameter such that when pressure is applied, the tip forces the conductors together, as shown in that figure. If the tip is too big, then it is believed that it might rest between two insulators 20 without causing a closure event of two of the conductors 12, 18. Pressure from a finger tip suffices to cause a closure event because it is believed that the skin at the finger tip under pressure conforms to the insulators 20 enough to cause sufficient flexing to cause the conductors 12, 18 to touch. The contact of the conductors 12, 18 identifies a unique location on the X-Y axis of the touchpad to within the accuracy or resolution of the width of the conductors 12 and 18. The electrical circuitry and logic for such determination will be described presently.

The spacing and width of the conductors is selected based on the precision or resolution of the location desired to be identified. Of course, the more conductors per unit area, the more precise the location that can be identified that is being touched, i.e., the greater the resolution that can be achieved. In a typical touchpad, a desirable size is where the copper x-conductors 12 are about 0.008 inch wide, with the spaces therebetween being about 0.012 inch wide, which provides 50 lines per inch. The width of the y-conductors 18 on a typical embodiment is 0.012 inch, with the insulators 20 being 0.008 inch wide, thus also providing 50 lines per inch on the flexible membrane 16. It is believed that the conductors at a maximum can be approximately 0.25 inches wide, with the above-mentioned gap 22 of 10 micrometers.

In the above embodiment, the conductors are preferably equally spaced and of equal width. In the alternative, one or more of the x- or y-conductors can be much thicker. For example, if a region of the sensor is intended to be a row of dedicated function keys or icons, as is known in the art, a single x-conductor 12 can be as wide as the keys or icons. The coarse x-conductor can be printed with and adjacent to the fine x-conductors, as described above, and placed proximate to the y-conductors 18, separated by the insulators 20.

As will be described presently, the electrical circuitry and logic to determine the exact location of contact between conductors 12 and 18 performs a polling function of the various conductors 12 and 18 to determine where the contact is. While this is relatively fast, nevertheless in some instances, it is desirable to decrease the polling time and thus decrease the response time, especially where traces, such as handwriting, are to be mapped. In addition, in high-density sensors using discrete drivers and receivers, the number of electronic device pins becomes very high. For example, a 640 by 480 sensor would need 640 drivers and 480 receivers for a total of 1120 discrete device pins. Thus, it is also desirable to provide a touchpad sensor that requires fewer pins, yet maintains the simplicity of discrete drivers and receivers.

To these ends, the embodiment of touchpads shown in Figures 2A-2E are provided which, together with circuitry and logic which will be described presently, substantially reduces the time required for the determination of the location of a touch and significantly reduces the complexity of the required circuitry. In this embodiment, there are two sets of pairs of superposed conductors, each of which sets are actuated by a single touch of a stylus or finger or the like. One set is divided into very coarse or broad areas, i.e., having a rather coarse resolution, and the other set is divided into finer or narrow areas, i.e., having a rather fine resolution. As will be described presently, the coarse areas of resolution are polled to determine the general location of the touch, and the finer areas of resolution within the detected coarse area are polled to determine a more precise location within the general area. This substantially reduces the time needed to determine where the touch has occurred, thus decreasing the response time to a touch in any particular area as will be described presently with respect to the circuitry and logic.

Referring now to Figures 2A-2E, an embodiment of the dual sensor of the present invention is shown. A substrate 30 is provided which in one embodiment is a glass filled epoxy printed circuit board such as the type previously described. Disposed on the substrate 30 are a plurality of copper coarse x-conductors 32 which are formed as previously described by any suitable technique, such as photolithography and the other printed circuit board fabrication steps mentioned above in regards to the conductors 12. A flexible membrane 36 is provided which is similar to membrane 16 of the previously described embodiment and which has formed on one side 37 thereof coarse y-conductors 38, separated by resilient insulating strips of material 40. In Figure 2C, certain parts, including a portion of the coarse y-conductor 38, have been partially cut away for clarity. The coarse y-conductors 38 are preferably formed of conducting ink similar to the conductors 18 and the resilient insulating strips of material 40 are preferably the same material as the material for insulating strips 20 in the previous embodiment. Up to this point, the structure is substantially similar to that of the previously described embodiment, other than the width of the conductors 32 and 38 which are substantially wider than in the previous embodiment for a purpose which will be described presently.

Disposed on the opposite surface 41 of the flexible membrane 36 are another set of spaced longitudinally extending conductive materials or lines 42. These fine x-conductors 42 are formed by conventional conductive ink screening as previously described and are spaced and separated by an air gap (not shown) as are the conductors 32.

A second flexible membrane 46 is also provided on which longitudinally extending fine y-conductors 48 formed of conducting ink and separated by resilient insulating strips 50 are disposed. In Figure 2C, certain parts, including a portion of the fine y-conductor 48, have been partially cut away for clarity. The strips 50 are deposited, as described above, between the conductors 48 and positioned adjacent to the conductors 42. In the alternative, the resilient strips 50 can be deposited between the conductors 42 and positioned adjacent to the conductors 48. The fine y-conductors 48 are positioned skewed and preferably orthogonally with respect to fine x-conductors 42. In this embodiment, there is an upper gap 52 between the upper conductors 42, 48, and a lower gap 54 between the lower conductors 32, 38. The gaps are as described in the text accompanying gap 22. In this embodiment, the width and spacing of the fine x-conductors 42 and the fine y-conductors 48 are substantially the same as the width and spacing of the conductors 12 and 16, respectively, in the previous embodiment. The width of coarse conductors 32 and 38 are selected such that they each are wide enough to encompass more than one and preferably up to 16 of the fine conductors 42 and 48, respectively. Thus, any contact between coarse conductors 32 and 38 represents potentially 256 contacts between fine conductors 42 and 48 (i.e., 16 x 16 = 256). Hence, when a gross area of contact has been identified by contact between coarse conductors 32 and 38 only the fine conductors 42 and 48 which have the possibility of being contacted, i.e., those fine conductors 42 and 48 which are within the gross area need to be polled--rather than all of the fine conductors 42 and 48 as is necessary in the previous embodiment when all of the conductors 12 and 18 need to be polled.

As can be seen in Figure 2E, when the stylus 24 puts pressure on the flexible membrane 46, the deflection or deformation therebeneath of both membrane 46 and membrane 36 causes a dual or double superimposed contact action to take place. In one contact action, one of the coarse y-conductors 38 contacts one of the coarse x-conductors 32, and also one of fine x-conductors 42 contacts one of the fine y-conductors 48. As will be described presently, circuitry preferably provides for a polling first to determine the location of the contact of the coarse conductors 32 and 38, to determine a general area of contact. When a general area of contact has been determined, the specific area or more localized area of contact is determined by the location of the contact between the fine conductors 42 and 48.

Further, it is to be understood that the selection of specific materials may vary depending upon the specific characteristics desired in the touchpad.

Just as one example, in the alternative, it may be desirable to have the entire touchpad flexible rather than have a rigid base. Such a sensor might be flexed and affixed to a nonplanar surface such as a cylinder or the viewing surface of a cathode ray tube or other display device.

As shown in Figures 3A-3B and 4A-4B, in such a case, the substrate 10 or substrate 30 can be replaced with a more flexible substrate 10' or 30', respectively, which indeed could be the same material as the flexible membranes 16, 36 and 46. In this case, the conductors 12 and 32 would be replaced with a more flexible conductor 12' or 32', respectively, which indeed could be the same material as the flexible conductors 18, 38, 42, and 48. Moreover, if more transparent materials are selected, this would provide some degree of transparency to the pad if so desired. Transparent inks well known in the art of LCD panel design allow fabrication of an essentially transparent unit Other techniques and other conducting material can be used as can other resilient materials be used between the conductors. Also in the alternative, if desired, resilient strips of insulating material can be placed between conductors 12 and 18 or 32 and 38 on the substrate, as shown in Figures 3A, 3B, 4A, and 4B.

In the alternative, the central substrate 36 can have both conductors and insulators on both sides with the other two substrates 30, 46 only having conductors thereon. Many combinations and permutations are possible.

Referring now to Figure 5A, a block diagram of the electronics used to interface to the touchpad sensor is shown.

In circuit communication with the y-conductors 18 are y-scan drivers 102, one driver per conductor. The y-scan drivers 102 comprise a 244-bit self-starting ring counter, which is configured to pass a single logical ONE around the ring responsive to complete cycles of a YCLK 104, which is a free-running square-wave oscillator. As the logical ONE is passed around the ring, the y-conductors 18 are sequentially raised to a voltage corresponding to the logical one. As each y-conductor 18 is raised to a logical ONE, the YCLK 104 also causes a y-counter 106 to count. The y-counter 106 is a binary up counter configured to reset after counting 244 cycles of the YCLK 104. Thus, the value of the y-counter 106 is the number of the y-conductor currently at a voltage corresponding to a logical ONE.

Likewise, in circuit communication with the x-conductors 12 are x-scan receivers 108, one receiver per conductor. The x-scan receivers 108 comprise a 320-bit parallel load/ serial shift register (PLSSR). During the time each y-conductor 18 is at the voltage corresponding to a logical ONE, the value of each of the x-conductors is latched into a corresponding bit of the PLSSR. Immediately after latching, all the x-values are shifted, one at a time, responsive to complete cycles of an XCLK 110, which is a free-running square-wave oscillator. As each individual x-conductor value is shifted, the XCLK 110 also causes an x-counter 112 to count. The x-counter 112 is a resettable binary up counter configured to count up responsive to complete cycles of the XCLK 110. Thus, the value of the x-counter 112 is the number of the x-conductor currently being shifted out of the PLSSR.

If the y-conductor that is being driven to a logical ONE is touching one of the x-conductors in the manner shown in Figure 1E, then one of the latched x-conductor values will also be a logical ONE. On the other hand, if the y-conductor that is at a logical ONE is not touching one of the x-conductors in the manner shown in Figure 1E, then all of the latched values will be a logical ZERO. Thus, if one of the x-conductor values is a logical ONE, then at the moment that one bit is shifted out of the PLSSR, the y-counter contains the y-coordinate of the touched region and the x-counter contains the x-coordinate of the touched region. Therefore, the counters are configured to disable counting responsive to a logical ONE being detected at one of the x-conductor values.

The coordinates stored in the disabled counters 106, 112 are latched into a y-latch 114 and an x-latch 116. The values are read by a microprocessor 118 or some other suitable processor and are transmitted via an RS-232 driver 120 to the attached personal computer (not shown).

Referring now to Figure 5B, a schematic circuit diagram of one embodiment of the circuit if Figure 5A is shown. In this embodiment, the circuitry is implemented in eleven programmable logic devices (PLDs) 130a-130k, a microcontroller 132, and an RS-232 driver 120. All electronic devices are properly powered by a suitable power supply and power inputs are properly decoupled with decoupling capacitors (not shown), both of which are well known in the art.

The microcontroller 132 is an SC80C51FB-4F40, which is a programmable 8-bit microcontroller manufactured by Philips Components, Ltd., Mullard House, Torrington Place, London WC1E 7HP, United Kingdom, and is available from many distributors. Other microcontrollers can be used. The RS-232 driver 120 is an AD232-JR, manufactured by Analog Devices, One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, and is available from many distributors. Other RS-232 drivers can be used to drive the signals to proper RS-232 levels, as is known in the art. The PLDs 130a-130k are MACH230 PLDs, which are manufactured by Advanced Micro Devices, 901 Thompson Place, P.O. Box 3453, Sunnyvale, CA 94088-3000, and are available from many distributors. Other devices

can be used to implement the circuitry.

The devices are connected in circuit communication, as shown in Figure 5B. As shown in that figure, each of the y-driver outputs Y0-Y239 are connected to one of the y-conductors 18 via a small signal diode 136. The diodes 136 prevent damage to the EPLDs if two or more y-conductors are shorted together. Likewise, each of the x-receiver inputs X0-X319 are connected to one of the x-conductors 12. Each of the x-conductors are pulled down to a logical ZERO via a 10K pull-down resistor 138, to prevent the inputs of the x-receivers from floating.

Also shown in Figure 5B is a DB-9 connector 140, a pair of switches 142, 144, and a 10K pullup resistor 146, all in circuit communication as shown in that figure. The DB-9 connector 140 is used to connect the signals of the touchpad to a personal computer (not shown) or other device receiving coordinate data via a multiconductor cable.

The switches 142, 144 are used as supplemental inputs, similar to the buttons on a so-called "mouse" pointing device. Periodically, the microcontroller 132 reads port P1.7 to determine the state of the switches 142, 144 and sends an RS-232 signal corresponding to the switch state out of its TxD output, as is well known in the art.

The circuitry of the y-driver PLDs 130a-130e is shown in Figure 5C. As shown in that figure, the SAMPLE, XCLK, and YCLK signals are generated by a clock circuit 150 from a 16 Mhz digital signal 152. The 16 MHz signal 152 can be generated by a hybrid oscillator, a crystal and several inverting Schmitt triggers, and other methods well known in the art. The YCLK signal is a digital signal that has a 20.5 μs period and can be generated by decoding a signal that has a period that is 328 cycles of the 16 MHz clock signal 152. In this embodiment, the XCLK is the 16 MHz signal 152.

The y-driver circuit comprises 244 D-flip flops 154 that are connected in a self-starting ring counter configuration 156 with two inverters 156, as is known in the art and shown in Figure 5C. The 244 stages are divided between the 5 PLDs 130a-130e. If different density PLDs are used, more or fewer PLDs might be needed to implement all 244 stages. The last output of the previous PLD is connected to an input, labeled IN, of the next PLD by a ring counter connection 142, as is show in Figure 5B. The counter connections 142 allow the logical ONE in the ring counter 156 to be shifted through all 244 stages with only one data line connecting the PLDs.

The ring counter 156 generates the 240 y-driver signals Y0-Y239, the timing signals FSYNC1-3, and a DUMMY signal. The FSYNC signals are used for timing purposes throughout the circuitry. The flip flops 154 reset such that Q=0 on powerup; therefore, before first cycle of YCLK, the DUMMY signal, the FSYNC signals, and the Y signals are all a logical ZERO. After the first period of YCLK, a ONE appears at FSYNC1 and all the others remain a ZERO. After the next period of YCLK, FSYNC1 changes to a ZERO and FSYNC2 changes to a logical ONE. Successive cycles of YCLK cause the logical ONE to appear to be passed from one D-flip flop to the next, as is known in the art and shown in Figure 5D. As shown in that figure, each Y line (as well as each FSYNC and the DUMMY signal) is sequentially held to a logical ONE for 328 cycles of the 16 MHz clock (20.5 μs).

The details of the SAMPLE signal are shown in Figure 5E. The SAMPLE signal was generated using a binary up counter, combinatorial logic, and an R-S latch (all not shown), with the SAMPLE signal being the output of the latch. Such circuits are known in the art. Essentially, 318 cycles of the 16 MHz clock into the 328-cycle period of each Y line, the latch is RESET by the logic, thereby allowing the SAMPLE signal to fall low. Eight complete cycles of the 16 MHz clock (500 ns) later, the latch is SET by the logic, thereby causing the SAMPLE signal to rise high again. Two cycles of the 16 MHz clock (125 ns) later, Y_n becomes inactive and Y_{n+1} becomes active.

Referring back to Figure 5C the remaining y-driver circuitry is also shown. A y-counter 158 and y-latch 160 are placed in circuit communication as shown. The y-counter 158 is an 8-bit binary up counter with count enable and clear, as is known in the art. The y-latch is an 8-bit latching register, as is known in the art. An AND gate 162 generates a signal that latches the register responsive to the STOP and FSYNC1 signals, also as shown in that figure. In addition, an R-S latch generates 164 the DISABLE signal responsive to Y239 and FSYNC2, as shown.

Referring now to Figure 5F, the circuitry of the x-driver PLDs 130f-130k is shown. As shown in that figure, the x-receivers are implemented by a 320-bit parallel load/serial shift register (PLSSR) 170, an R-S latch 172, a 9-bit binary up counter 174 with count enable and clear, a 9-bit latching register 176, and an AND gate 178, placed in circuit communication as shown in that figure.

In this particular embodiment, the 320-bit PLSSR 170 is divided between the six PLDs 130f-130k. If different density PLDs are used, more or fewer PLDs might be needed to implement all 320 stages. The stages of the PLSSR 170 can be functional building blocks equivalent to the well known 74165. All six PLDs 130f-130k are connected to the SAMPLE signal and the six PLDs 130f-130k are linked serially by serial connections 180, shown in Figure 5B. The output, labelled O, of the previous PLD is connected to the input, label-